NEW CREATIONS IN PLANT LIFE

HARWOOD

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·The MM Co·

The improved amaryllis, with blossoms nearly a foot across and of great brilliancy

NEW CREATIONS IN PLANT LIFE

AN AUTHORITATIVE ACCOUNT
OF THE LIFE AND WORK OF
LUTHER BURBANK

BY

W. S. HARWOOD

SECOND EDITION, REVISED AND ENLARGED

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To My Wife

PREFACE

THE preparation of this volume has been a work of particular pleasure: First, because of the unusual interest which has centered in the development of the material, material which takes its rise in primal places and flows in a broad stream outward; and, second, and paramount, it has been a pleasure because of the contact it has brought with the man whose life and achievements it can but inadequately portray.

When the demands of his great work have been most exacting, he has never shrunk from giving still more of his strength to the illumination of obscure points; when the work has worn upon him so that it has taxed his energies to the utmost, while care sought out the strings of his nerves to play sharp discords upon them, he has never failed in patience or

yielded to the irritation that must have swept a lesser man off his feet.

For the unfailing courtesy, for the superb thoughtfulness, for the rare gift of clarity of speech,—for all these, and far more, I am under obligation to the man about whom this book is written. If it shall be an exposition of his great work which shall bring pleasure and possibly some measure of profit to those who read, and, beyond, if it shall point the way to a still wider extension of the work of which Luther Burbank is so conspicuous a pioneer and leader, I shall indeed be glad.

W. S. H.

PREFACE TO THE SECOND EDITION

THREE points may be noted in the presentation of this new and revised edition of "New Creations in Plant Life," which has passed through various printings during the period since the volume was issued a year and a half ago.

First, the statements in this volume, both those which have a scientific and those which have a practical bearing, stand unreservedly vouched for by Mr. Burbank.

Second, the interest in the man and his work has steadily heightened since the book was first issued, and a clearer and more intelligent appreciation of his great powers has been manifest. The interest has been shown not only in the practical features but in the scientific as well. The more closely his work

has been scanned by those who have been both competent and fair, the more commanding it has appeared in its scientific and economic value.

Third, a still closer study of the work during the period since the book was first issued demonstrates that this is one of the greatest constructive enterprises ever established among men. It is beyond the sweep of gigantic corporation projects, for, while from their development vast good may come, the temptation to misuse enormous powers and to sow corruption is so overmastering that that which must be the active principle in all true progress, the constructive, is liable to be overborne by that which blocks all progress, the destructive. With Mr. Burbank, notably in such instances as that of the development of the new cactus fully considered later, everything is constructive, everything is planned for the permanent good of man through all generations.

To those, and they are very many, who have written in print and in private with such

cordial and generous appreciation of the book, my most hearty thanks are due. To those few who have criticized without adequate knowledge I may only express the sincere hope that they may let themselves come to a fuller understanding of the man and his work, and thus be enabled to see that that which they may honestly have thought too high praise was, indeed, but a conservative appreciation; for he who deals with the life-work of Luther Burbank deals with that which is unique among the enterprises of the age, and of a noble and unparalleled scope.

W. S. H.

Los Gatos, California.

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CHAPTER I

LUTHER BURBANK, THE MAN

LUTHER BURBANK, of whose life, aehievements and methods this book is to treat, is the foremost plant-breeder in the world. Over two thousand five hundred distinet speeies are in the list of the plants upon which he has worked, embracing a large and comprehensive field of operations. He has also produeed more new forms of plant life than any other man, and has exerted a unique and powerful influence.

These new forms of plant life may be brought into two classes,—those which have added to the wealth of nations and enriched the dietary of the race,—as new and improved nuts, fruits and vegetables; and those whieh have made the world more beautiful,—the new and improved forms of flowers.

Without a university training and with only

a fundamental education upon which he has builded by wide reading, he yet leads the scientific world in the department to which he has given his life. He has suffered as few men suffer, not only from actual physical want and privation but from the unjust criticism of those who did not comprehend; but he has preserved through it all an unshaken confidence in the ultimate triumph of all good forces in human life. He has been engaged in a line of work so novel and so profitable he could easily have built up a fortune, yet he has subjected himself all his life to the most rigid self-denial and sacrifice in order that every energy and every resource might be devoted to the betterment of the world.

Luther Burbank was born in the town of Lancaster, Massachusetts, not far from the city of Boston, on the 7th of March, 1849. Two controlling streams met in the forming of the main current of his life. From his father, a cultivated man of English extraction, came an intense love for books; from his mother, whose ancestry was Scotch, an ardent love for all beautiful forms of life. These two hereditary influences have been at work all

through his life,—the one broadening, the other deepening his nature.

From the earliest childhood he was passionately devoted to flowers and to all forms of plant life. Very many incidents are related illustrative of this. His mother and sisters had noticed that whenever he was given a flower, while lying in his cradle, he always held it with a certain childish tenderness, never crushing nor dropping it but keeping it, if allowed, until its bloom was faded or its fragrance gone. One day when his sister had given him a flower he held it in his tiny fingers with his usual earnestness until a petal fell off. Then, with infinite childish patience, he strove to put the petal back in place and thus restore the flower. When a little older and able to walk, he often chose plants for pets instead of animals. He was given a plant in a pot, a so-called lobster cactus as the variety of cactus was locally known, and for hours at a time he trudged about house and yard carrying the cactus plant in his little arms. One day he stumbled and fell, broke the plant from its stem and destroyed the pot. It was a day of great sadness, for he

was as inconsolable in his grief over the loss of the pet plant as another child would have been over the death of a bird or a faithful dog.

Strangely enough, a half century later, in the prime of his manhood, he has given years of his life to the study of other forms of this pet of his childhood days, creating a series of thornless and bristleless cacti, forming a vast reservoir of food for man and for uncounted millions of the beasts of the field, and paving the way for the reclamation of the desert places of the earth. That which was once a dangerous foe of man and beast becomes, through him, a stanch friend;—it is a noble boon to the race.

Year by year, as he grew into boyhood, his love for all the beautiful things in the world around him steadily deepened. As soon as he was old enough to be placed in school, he at once attracted the attention of his teachers by his love for study. The love for his school and the love for the flowers and the trees and the birds were always manifest. And in the ripe days of his prime one may see him turn with boyish eagerness from the discussion of some

deep problem of human life to listen to the note of a lark in the sky.

By the time he had reached the age of twelve he had come to a knowledge of the outward forms of nature such as few lads ever attain at such an age. All the books he could command bearing upon any phase of science or nature he read and reread. The habit thus acquired has lasted. He may not be able to tell you the plot of the latest novel, but be sure he will be able to talk with you about the latest discovery of the scientists and to dissect their conclusions with consummate art. I can in no way better illustrate the trend of the lad's mind at that time than to say that in his maturer years the author which he has read most and which he quotes more often than any other is Ralph Waldo Emerson.

As a lad, he was not indifferent to the sports of other children, and entered heartily into many of them, though there was ever a greater fascination for him in the open page of a book than in rod or gun or ball. And greatest of all was the fascination of the natural world opening to him as it opens to the heart of a poet.

In the town of Lancaster there was a well-equipped academy to which he was drawn as soon as he had finished the common school. This he attended during the winter for several seasons, spending the rest of the year in work. The town had a large and well-stocked library, and into this, and into his father's few but carefully chosen books, he delved whenever there was opportunity. His father and his father's brother, a minister, were personal friends of Emerson. The uncle's son, the boy's cousin, considerably older, was greatly interested in science and was also a personal friend of Agassiz, afterward becoming a successful educator and a writer of more than local note on scientific topics, particularly geology. Between the two there was a strong bond of friendship. The influence of such surroundings had much to do in shaping the lad's nature. Year by year environment forces were at work, and in them may be seen the prophecy of the development of this wonderful life.

During several summers the boy worked in the city of Worcester, Massachusetts, in a factory. His wage was small and the work was hard and irksome, but he even then had his

ideals toward which he was working, and he kept on and up amidst many discouragements. He learned soon, however, that, as there were seven days in the week and as it cost him at least fifty cents a day to live, he could not get along very satisfactorily on a six-day wage of fifty cents. The bent of the boy's mind now seemed to be toward what his relatives and friends thought was invention, but which, though it included invention in the ordinary meaning of the word, was far beyond this in scope. When still younger, he was standing one day by the side of a number of his elders who were vainly trying to put together a mower. One piece of the machinery would not fit, and, after much trying, they were giving up, when the boy, rarely venturing a word of advice to an elder, stepped forward and suggested how the piece should go. It was put in place and the machine moved off.

When asked how he knew the piece of iron belonged in that particular place, he replied laconically:

"Because you couldn't put it anywhere else!"

Studying how he might make both ends

meet in the factory on his scant pay, he discovered a way to construct a machine which would do away with the work of at least half a dozen men. He made the invention, and his delighted employers followed with a substantial increase in his pay. They predicted for him, as did his friends, a brilliant future as an inventor, and all urged him to set about such a life. He has disregarded the advice of his friends in later years, as he did then; and he has never found reason for regret, even though the way he has traveled has led through pain and sacrifice.

Day by day in the midst of the toil of the factory, unswerved from his ideals by the promise of greater pecuniary reward, the dominant chord in his life was always sounding, struck as it was by the supreme purpose of his soul—to make new things better than the old, to make the old ones better than they were. All through a life no less scarred with sacrifice than adorned with triumph this same chord has sounded, deeper and broader in its harmony as the years have come, but not more true in the creation of marvelous forms of plant life than in the making of a machine to quicken and

cheapen the process of manufacturing a plow.

But there came a day he never forgot, a red-letter day in his calendar. He had left the factory and had begun market-gardening and seed-raising in a small way. It was far more to his taste and in direct line with the future. He had noticed that there were a good many variations in the green tops of some potatoes he was raising, and that in this particular lot there was but one which bore a seed-ball. He had already begun a close study of the characteristics of plants, and he at once reasoned that if this seed-ball came upon but one of all the varying plants, its product, if it should be planted, should show still greater variation. So he watched this seed-ball with unusual care. One day, to his despair, he found that the seed-ball was missing. He was about to give up the whole matter when it occurred to him he would make a search upon the ground. He found the seed-ball at last, where it had been knocked off probably by some wandering dog rushing through the garden.

From it came the Burbank potato, which comparatively few people associate with Luther

Burbank, the great plant-breeder. The potato which he developed from this seed-ball has not only disproved the dictum of those who said a potato famine was at hand because of the steady deterioration of the world's stock, but it has added to the wealth of this nation alone upwards of twenty millions of dollars. The creator of the new potato sold it to a local seedsman for $150.

It was not long after this that he suffered a partial sunstroke in the broiling heat of a July day and, seeking a climate where he might be able to live an outdoor life without fear of a return attack, and where he might hope some day to put in effect some of the theories of the development of plant life already stirring in his brain, he started for California, with a slender purse and ten of his new potatoes. He reached California in 1875, and went north from San Francisco some fifty miles to an unimproved valley lying between two spurs of the Coast Range Mountains, today a rich fruit and farming country.

He was then twenty-five years of age, slender, not over-strong, and yet possessed of much vitality and endurance. These latter he

was soon called upon to put to test. The country was new, and the few ranchers and farmers had not yet begun to realize the possibilities of their region in the way of fruit culture. He sought for work, that he might get ahead enough to make a start as a nurseryman. He saw the possibilities of the country in this line and the promise of a good living, and perhaps a competence if he could only get established. But work was not easy to get. Day after day he sought it and failed, and day by day his slender store of money ran down. He did all sorts of odd jobs, many of them far beyond his strength. He heard of a new building to be put up in the frontier town. He applied for work. He had no tools, but, being promised a job if he had a shingling hatchet, he invested nearly all of his remaining funds in one, only to find, the next morning, that the job had gone to some one else.

He found more steady work at last at a mere pittance, cleaning out chicken-coops on a chicken-ranch. The work was disagreeable in the extreme, but he was willing to do anything that was honorable. At this time he

had no place to sleep nights, and for months made his bed in a chicken-coop, unable to get enough money ahead to pay for regular lodgings. Occasionally, when work altogether failed, he was reduced to absolute want. It was his habit at such times to go to the village meat market, secure the refuse bones saved for dogs, and get from them what meat he could.

He found steady employment at last in a small nursery at a beggarly wage. Not being able to hire lodgings, he slept in a bare, damp, unwholesome room above the steaming hothouse, where for days and nights at a time his clothing was never dry. He was passing through such privations as those through which, in the strange allotments of fortune, many another great man has passed.

The constant exposure and lack of nourishing food made rapid inroads upon a not too strong constitution, and this, with overwork, brought on an attack of fever. A woman in the neighborhood, herself in straitened circumstances, found him one day in such a critical condition that she insisted on sharing with him the small portion of milk which she could afford to spare from the one cow that supplied

her family. He protested against taking it because he might never be able to repay her, and, indeed, there was scant hope in his condition that he would live to do it. The woman insisted, and the pint of milk a day which she brought to him saved his life.

The man who was to become the foremost figure in the world in his line of life, and who was to pave the way by his own discoveries and creations for others of all lands to follow in his footsteps, was a stranger in a strange land, close to starvation, penniless, beset by disease, hard by the gates of death. And yet never for an instant did this heroic figure lose hope, never did he abandon confidence in himself, not once did he swerve from the path he had marked out. In the midst of all he kept an unshaken faith. He accepted the trials that came, not as a matter of course, not tamely, nor with any mock heroics, but as a passing necessity. His resolution was of iron, his will of steel, his heart of gold; he was fighting in the splendid armor of a clean life.

It was a wan and haggard figure that rose at last from his sick bed and wandered from place to place in search of work. Matters

shaped themselves gradually, more and more in his favor and he went from one odd job to another, slowly saving a little money and regaining his health. The day came at last when he had a bit of a balance in the bank and soon after he was able in a small way to set up in business for himself.

He secured a small plot of ground and established the nursery which was to become famous throughout not only his own state but the country at large. His heart was in his work now, but there was something else. All through these years of early manhood, in the midst of discouragement and privation, he never let go of the plan of his life—to become not merely a raiser of plants but an improver and a creator. Even in those first days, as chance offered, he began that wonderful series of experiments which has astonished the scientific men of two hemispheres and established an epoch in the life of the vegetable kingdom from which the future will reckon.

One day there came to the young nurseryman an order in the filling of which he displayed that boldness of plan and audacity of execution which have many a time marked his

progress. The order was from a man who was going to start a large prune raneh. He wanted twenty thousand young prune trees to set out. It would take in the ordinary eourse of events from two and a half to three years for a nurseryman to raise the trees, but this was a hurry-up order; if it was to be filled, it must be filled in nine months.

He took the order. With all haste he scoured the country for men and boys to plant almonds. It was late in the season and the almond seed was the only one which would sprout at that time among all the trees that were suitable for his plans. It grows very rapidly, too, and this was taken into account. In a eomparatively short time the young shoots were big enough for budding. Twenty thousand prune buds were in readiness, were budded into the growing almonds, and the young trees started forward in their raee for the prize. When the nine months were up the twenty thousand prune trees were ready. Nature had been outwitted, or, better put, had been led to outdo herself; the fruit-grower was delighted ; the young nurseryman was a good many dollars in poeket. Today, twenty years afterward,

one of the finest prune orchards in California or the world is growing from these trees.

It was a concrete illustration of the resourcefulness of the man and of that which has again and again been shown in his later life, his supreme indifference to precedent.

He early established an unvarying rule, never to send out anything which was not, so far as lay in his power, precisely what it was represented to be. So his name became a synonym for exact honesty,—if it came from Burbank, it was to be depended upon.

An incident well illustrates the confidence men had in him when once they came to know him. He was in need of some extra money to use in carrying forward a branch of his work. He had applied for a loan unsuccessfully at quite a number of places. His very modesty and shrinkingness, in the eyes of a business man, stood against him. One day, when he had given up hope of the loan, he saw a team of horses in the distance coming down the dusty road. As the team drew near he recognized a man who lived in the region, by common reputation a miserable old skinflint. Hailing from the road as he drove up, he called out;

"Say, young feller, I've been watchin' you a long time. You're allus attendin' to bizness. But a man that kin do what you kin do oughter have an easier time than you're havin'. Don't you need a little extry cash once in a while?"

Greatly interested in such a query from such a man, he answered that he could use a little additional money now and then,—in fact, he knew where he could put a hundred dollars that very day, in a place where it would bring in a handsome return.

Pulling out an old wallet, the so-called skinflint counted out two hundred dollars and handed them to the astonished nurseryman.

"No," as he drove off, "I don't want no note, nor no intrust nuther: when you git ready to pay it, all right. G'long, there!"

The years now rapidly passed. The business began to yield more handsomely, and yet he was less and less satisfied with the outlook. In the midst of the exacting demands of his work, he yet found time to devote to experimentation with new forms of plant life,—always before him the supreme purpose of his life. Reticent by nature, though never secretive, he did not talk over his new ideas with

any one. No one was to know what he was engaged in until such time as he had something to show for it.

As he had opportunity, he read such few practical books on botany and the breeding of plants as he could find, but these, save in some matters of nomenclature and detail, were of little aid to him. He soon found out that he stood face to face with Nature, and only from her lips could he learn her secrets.

He read Darwin among other scientists, and was greatly interested in the Origin of Species. In his own mind were developing, at the same time, important theories, which must be noted in a later chapter. Even as he worked the hardest, and all unknown to himself in large measure, his own mind was being broadened and deepened. He saw before him now something of the possibilities of plant creation—his vision was strong and true, his perspective never distorted.

There came another red-letter day in his calendar. It was the day when he came to the formal decision that he would give up his nursery business and devote his entire time and energies to plant-breeding. As soon as his

relatives and friends heard of his decision, they entered vehement protest. What greater folly could a man commit than to abandon a business now netting him nearly ten thousand dollars a year to embark upon a project at the best Quixotic and sure to end in financial ruin? It was the same sort of reasoning he had listened to when a boy, when his friends and relatives pictured a great career as an inventor.

Ridicule, pity, scorn, harsh criticism, all were alike unavailing. He listened with patience, but went forward in the line he had marked out. So one day in the year 1893 he found himself free from the exacting demands of his business life, his extensive nursery closed out. He had entered upon a career which was to be even more exacting than this business life, but he entered upon it high in hope and rich in resolution.

Slowly he put into effect his plans. Having tested a new fruit or flower or an improved old one, he kept it back, following in his old lines as a nurseryman, until he was absolutely sure it was going to do precisely what he said it would do. Not until then was he ready to

put a new creation before the world. The new and improved varieties were sold to bring him revenue for the further prosecution of his work. The sums for which they sold were ridiculously small, considering the time consumed in their production, often years of the most patient study and experimentation, and the large revenues that were derived from the new creations by the dealers purchasing them. Perhaps from one hundred dollars, at the start, up to five hundred would be an average. Orders soon began coming from Europe, where he gradually became better known, where, indeed, he was appreciated as he had never been in his own country.

His income rose steadily, but it did not match his outlay. There were laborers' wages to pay, supplies to be bought, funds provided for paying for the services of collectors in foreign lands, on the lookout for new kinds of plants. His reputation was advancing, but year by year he was falling behind and encroaching more and more upon the store set by for the rainy day.

Opposition now came from many quarters. Not only did his friends see the fulfilment of

their predictions,—some of them very kindly telling him so,—but people who had heard of some of the strange things he had done, and who had not the breadth of vision to see what manner of man this was, pronounced him a charlatan,—a man who was creating all manner of unnatural forms of life, monstrosities, indeed a distinct foe to the race. A minister invited Mr. Burbank to listen to a sermon on his work, and when the guest was in the pew denounced him in bitter fashion as a man who was working in direct opposition to the will of God, in thus creating new forms of life which never should have been created, or if created, only by God himself.

Now and again arose some pseudo-scientific man who, professing unlimited friendship, sought for means to filch the rapidly increasing reputation. Others visited him with the covert purposc of cxposing him as a charlatan after inspecting his methods, but, confounded by what they saw, went down the little hedge-bordered walk that leads to his quiet home shamed into silence. From various sources came offers of aid; but the keen vision of the man read every proposition in its spirit as well

as its letter and detected unerringly the efforts which, while apparently in his behalf, were in reality essentially selfish, planned so that others might profit by his experiences. There were strings to them; he would have none of them. He could divide responsibility, and apportion duty, but he could not yield authority. It would be fatal to have any other will than his own in command.

But he was learning now that, to accomplish the work he had mapped out, and so to leave it that others could take it up where he left it and carry it forward, it was imperative that he have assistance. Already many millions of dollars had been added to the national wealth because of his improved fruits. Already the whole world was being brightened by his flowers. And yet, if he should be able to work without handicap, the future promised far greater results than the past. Now and again, too, he was bitterly admonished that he could not work eighteen hours out of the twenty-four. Occasional illnesses came. He found that the nature he loved so well could chide as well as cheer. Several times he was laid by with dangerous nervous breakdowns.

At this point a plan was unfolded to him, considered somewhat at length in a later chapter, for substantial assistance from the Carnegie Institution in a manner which would leave him absolutely his own master and would enable that organization to become a silent partner in the furtherance of his plans.

Thus the way opened to a maximum of effort at a minimum of waste.

CHAPTER II

GENERAL METHODS OF WORK

BEFORE passing to the individual creations of Mr. Burbank, it will be of interest to consider the general plan of his life-work, reserving for later chapters the minutiæ of the methods, so presented and so fortified by advice from Mr. Burbank that the amateur, no less than the professional, may receive suggestions for the prosecution of plant-breeding, one of the most fascinating occupations in the world, and one full of great practical possibilities. Indeed, as Mr. Burbank puts it, results of enormous value to the race may at any time come from the work of any man who takes up plant-breeding with patience and intelligent interest.

The aim of Mr. Burbank, aside from that paramount object always overshadowing all else, to give aid to the race, is threefold:

1. The improvement of old varieties of fruits, flowers, grasses, trees and vegetables.

2. The merging of wild, or degenerate, types of plant life with tame, or cultivated ones, in order that the union may be of service to both.

3. The creation of absolutely new forms of life, unknown to the world before,—the highest act of the plant-breeder.

The general character of his work is included under two heads:

1. Breeding.—This, in its basic meaning, consists in uniting two plants to give birth to a third. A thousand and one things must be taken into account, all accumulating through hereditary influences and environment, and reaching out through all the future life of the plant; but, for present consideration, the chief act is parental. Breeding is accomplished by sifting the pollen of one plant upon the stigma of another, this act, pollenation, resulting in fertilization, Nature, in her own mysterious ways, bringing forth the new plant.

2. Selection.—This consists in eternally choosing the best and rejecting the worst. It is co-equal in importance with breeding, the one supplementary to the other at all points.

The breeding of plants is not a new art.

Generally speaking, however, those who have carried it on have worked in small quarters, perhaps in gardens or conservatories, usually with comparatively few varieties. Mr. Burbank early saw that this was slow work, that it would take the years of many lifetimes to accomplish what he had laid out before him. The sending of telegrams was once confined to a single message, one way, in one direction. Even this was a wonderful thing, but it was slow, and so there was devised a system of sending many messages upon the single wire in both directions at the same time.

Some such transformation as this he has wrought in plant-breeding.

Instead of one or two experiments under way at the same time, he may have five hundred at once, all requiring constant supervision, many of them extending over a period of perhaps ten years before they come to fruition. Instead of having a few square feet of ground or a few pots under glass, he uses acres of ground, if necessary, in a single test. In place of contenting himself with a half dozen, or even fifty plants, in making a given test, he uses if necessary a million, all of them

pressing forward in a million similar ways, toward the same end. And out of the million he saves perhaps in the last sifting but one, and that one the best of all.

Running through all the work is the constant effort to break up old habits of life. Mr. Burbank sees two plants of the same, or it may be widely differing, species. He sees that neither one is living up to its opportunities. For one reason or another they may have made no perceptible progress, possibly for centuries; or else it may be they have been as slowly going upward from some poorer estate and have not had sufficient help. He knows that back of each one of these plants lies a long and varied history, full of incidents, replete in experiences as strange in their way and as subtle as any which come to man. This past of the plant has produced the plant of today—tomorrow it must be changed.

Just as into the life of a man long inured to bad habits, the son of evil parents, tracing his lineage backward through a century of sin, just as there must come into this life some tremendous shock, be it a death, a terror, a great love or an overpowering hate, completely

changing the course of his life and making an abrupt break in the generations of crime, so in a gentler but none the less powerful manner the plant must have the overpowering shock of re-creation, it must irrevocably break with the past. As in the case of the man, so with the flower. The initial shock and subsequent change may be followed by a reaction and a return in some measure to the old order of things; but just as care and patience and wise living and the higher aid may help the man back and steady him in a course of right living, so the plant, though it rebel at first, finally becomes fixed in its new ways and starts forward to enrich or glorify the world.

The very least of Mr. Burbank's labor is the actual breaking up of the plant's life by the shock of re-creation, the vastest in its scope that a life can bear, such shock as even death does not bring, for it is death and life in one, the death of the old and the birth of the new. But this, however grave a change, is only an incident in the work. He must study the plant in all its relations. He must know its past intimately. He must take into account ten thousand past tendencies. He must look

to the future of the new plant and see in what manner it is to fill out its new place in the world among its fellows and amidst perhaps radically different environments. These plants are like children. To know them you must know their ancestry; and to know their ancestry affords at least some hint of their future. In a plant, this past, this heredity which Mr. Burbank, more clearly than it was ever set forth before, pronounces "the sum of all past environments," is perhaps more fixed than that of a child's past, because it has not had so many obvious disturbances. It has not been subject to the inconsistencies of human love and its strange selections. This knowledge of the past of the plant and this intimate study of its life and the related life of other plants are among the factors which help to give Mr. Burbank the commanding place he holds in the world.

When the past of the plant has been broken up, then comes the turning of its life forces into its new channels. Indeed, when we begin to search for the secret of Mr. Burbank's success, we find that it lies deep, and sweeps forward with a powerful hold upon the very sources of life itself. Perhaps the flower he is

for the time considering has had a small, insignificant blossom all its life, all the life, anyway, that is recorded by man. Its life tendencies have centered and culminated, so to speak, in this pitifully inadequate bloom. The blossom is not only small and unattractive in form but weak in color, hard by the realm of the outcast weeds. But he has seen in it great possibilities; swiftly he sets about its improvement. Possibly he sees that by combining it with some near related flower friend he may make it lovelier, perhaps he decides that the only way to do is to pick out the very best of its kind from among a thousand or ten thousand plants and from this best one, poor though it may be, go on and on in a constant succession of upward selections from the plants that follow the seeding, until at last he brings forth the blossom he sought, beautiful, large, richer in color, fine and velvety in texture, a royal addition to the blossoms of the world.

It takes long to do this,—perhaps twenty years. Twenty years to produce a new flower? Certainly, why not? Is it not worth it? Not that he may spend his whole time for that term on a single plant,—a whole series of them

is in process of development at once, hundreds of varieties. But it is years in almost every case before the end is reached,—so slow the work of selection from year to year, this eternal choosing of the best plants from the best.

And there are many obstacles. When two plants are united to produce a third, no human intelligence can predict just what will follow. You have in the hollow of your hand a dozen seeds from one of your choicest apples. It had reddened in the autumn sun on a tree you had known since boyhood. You had watched it blossom in pink beauty in the springtime of other years, had seen its fruit develop in the mellowing summer, had watched its bare branches tossed in the gale when the winter snows lay deep at its feet. Here in your hand lie the seeds of this apple. It may be you are a thousand miles away from the old home where the apple tree is growing. It would be a rare delight for you, transplanted to another region, and for your children after you, to raise another tree from the seeds of the old friend. So you plant your twelve seeds to rear on a new soil the old friend, and not one of them comes into a life in any particular like the

life of the old tree at home—indeed, it may turn out not one of them bears fruit fit for the tongue.

So it may be with a new life from cross-breeding and selection,—the end cannot always be foretold. But Mr. Burbank does not content himself with the use of two or three plants as stock, taking chances on their failure to make progress. Many men have used a few plants and have found certain results following, and now and again has arisen one who, from his few experiments, has reached certain results which entitle his deductions, he believes, to be known thereafter as laws. Mr. Burbank has never worked in this way. He early saw that to carry on his plans in the broadest and best manner, to avoid the delays incident to a failure of a single plant to show improvement, he must work with thousands where necessary, indeed, with tens of thousands; indeed, more than this, with a million plants if needs be. For example, in breeding lilies he has used as high as five hundred thousand plants in a single test. Out of this enormous number there naturally were great variations, and so before his eyes spread out a vast panorama,

rich in varied opportunities for initial selection. Out of this initial selection he makes final choice of the best.

Sometimes he has marked out a certain line of life for a flower. He has bred and selected to that end. For a time all goes as he had planned, but suddenly a new trait develops, something which completely throws all former plans out of gear. He does not abandon the test, but watches with the intensest interest the new development. If the plant persists in its way,—and the new way is better,—he leaves the old and follows the new. No man is quicker to give up, when convinced that giving up is best. But he is not convinced easily;—the evidence against him must be unanswerable. Now and then out of the muck of some slum, reeking with moral filth, and developing with unwholesome rapidity the seeds of anarchy and crime, a white, pure life springs up, persists, maintains its guard against all temptations, comes back, mayhap, in later years to help redeem its birthplace. And so in a similar way a flower sometimes breaks away from the line of life all logic and reason would say it should follow.

The new plant may develop certain characteristics like those of one parent, certain others like those of the other parent. It may inherit length of stem from one, breadth of leaf from the other, or it may have stem and leaf wholly unlike either. And this latter is frequently the end sought,—to produce a different type from that of either and from that produce by long selection a type superior to either parent. Very much of breeding is breaking up.

I recall with interest a conversation with a gentleman in the city of London concerning the terrible depravity among the young men of that city. There were at that time fully eight hundred thousand young men in the city between the ages of eighteen and twenty-five. He was perhaps better acquainted with the youth of the greatest city in the world than any other man in it. He said, as the result of his years of experience, that, but for the inflow of country blood into the veins of London, London life would become practically extinct in three generations,—so vast the vice.

Just as this, and all other great cities, are strengthened physically, mentally and, indeed,

morally, by the influence of those who are born and reared in country places, so, many times, a plant which has long lived in a careless civilization having lost its vitality, needs a new infusion of blood. Mr. Burbank has ever been a close student of all the outward forms of nature, as well as of all her strange inner life. All through all the years he has been working upon the flowers and plants he has found in the open, using them frequently for this very purpose to strengthen the strain of some over-civilized plant needing the fresh impulse of the wild, strong neighbor of the mountains or forest. Collectors in all quarters of the world, too, are steadily on the lookout to provide him with plant life from their regions, sometimes wild, sometimes tame, with which to make combinations or developments.

So he is confined to no one species nor to any one line of combinations. The whole world is his field, and he makes his selections and forms his combinations in absolute disregard of all precedent. The end in view is the point, how to reach it most directly. It may be along so-called scientific lines, it may be in absolutely new and original paths,—

more likely the latter,—but the means are the non-essentials, the end is paramount.

It will be seen that in order to accomplish the results that are changing in many ways the plant life of the world and opening the way to still greater changes, something else must enter into the matter than mere observation, however keen, than knowledge, however deep, than experience, however broad. And this strange, intangible thing, for want of a better term, we call intuition.

There comes a day each year in Mr. Burbank's work when the fruit trees under test, for example, must come up for scrutiny. Selection is to be put to one of its uses. Selection, selection of the best, must be ever operative from the time the plant is first chosen from its fellows;—it is the continual survival of the fittest; but now comes selection on a larger scale. Perhaps there are a hundred thousand of these fruit trees one or two years of age. They have been planted at Mr. Burbank's proving grounds at Sebastopol, a few miles from his home in Santa Rosa. They have been cared for with patience and with trained minds working over them, and

Twenty thousand new varieties of plums in process of development

now has come their crucial test: each one must pass in review before the eye of their master.

In the ordinary course of plant-breeding each one of these hundred thousand plants would need to be grafted, or budded, each one would need individual care. It would require at least five years before the final test would come and a showing be made of the value, or the worthlessness, of each particular tree. While no such test in a single experiment has ever been made, it may be stated in general terms that to graft and carry through to the end of the five-year period a hundred thousand trees would involve an outlay in actual money, and in rental value of the large area of ground necessary at least ten dollars per tree—a total of one million dollars.

This is saved by Mr. Burbank in one working day. It is saved by that faculty which is best expressed by the term intuition. With assistants to bring and carry away the tiny slender trees, perhaps now grown to a height of one to three feet, he passes upon the hundred thousand in a single day, going over them with lightning-like rapidity, challenging

them the instant they meet his eye, determining instantly whether or not they are fit to live. This is selection in one of its most important forms and carried on as it never has been carried on before.

Instantly he detects faults and as quickly determines excellencies. How does he do it? How does a child know enough to shun an evil man? How does a maiden know whether the man setting siege to her heart is to be trusted with her life? How does a man of sensitive fiber know instantly, without word or sign, that his traveling companion is a cutthroat by nature, whether or not he wear a bandit's garb?

Mr. Burbank decides upon his trees by intuition. He puts a case this way:

You may meet a hundred men, a thousand, or even ten thousand men upon the street of a great city, and instantly, without taking into account any particular feature, you know that they are different. No matter how similar in general, the line of difference is absolute. A hundred men pass before a merchant seeking a man for a position of trust—he can tell at a glance and with seldom an error whether or

not he is going to want any one of them. He does not know how—he simply utilizes his intuition; and Mr. Burbank can tell his trees with even greater accuracy.

One day a loyal friend laughingly suggested a test. He was not in doubt as to Mr. Burbank's word, but he would like visual demonstration. So a series of trees was passed before Mr. Burbank in the usual way. These he instantly separated into good, mediocre and poor. They were all grafted or budded in the usual way and then, after several years, when the time for final test came, the results showed that, in every instance, he had decided the precise nature of the tree and its relative value.

When the long period of a given test has been concluded, the rejected plants, shrubs or trees are gathered in large bonfires and burned, and the ground stands clear for another test. In a single year as many as fourteen of these huge bonfires have been lighted upon the hills of Sebastopol, consuming hundreds of thousands of plants. And out of all that entered the test, probably not more than one or two have been saved,—all

the rest have been rejected because they did not show improvement over old forms, because they did not promise to add anything to the beauty or the utility of the world. One plant out of five hundred thousand, all the rest destroyed, the results of all the labor of a decade ending in smoke,—no wonder the people living hard by, before they came to know what it all meant, pronounced this strange man going up and down their country lanes so gently and silently, a wild, erratic creature—indeed, more than one sagely held him bereft of all sound judgment.

Before passing to a more detailed consideration of Mr. Burbank's great achievements it will be of interest to note briefly some of his leading creations. The list includes:

The improved thornless and spiculess edible cactus, food for man and beast, to be the reclamation of the deserts of the world; the primus-berry, a union of the raspberry and blackberry, the first recorded instance of the creation of a new species, together with the phenomenal berry created from the California dewberry and the Cuthbert raspberry, and the plumcot, the union of the plum and the

apricot, all three the accomplishment of what had been said to be an impossibility; a plum with no pit, one with the flavor of a Bartlett pear, one having a rare fragrance, many plums of great value, rapidly replacing older varieties; a walnut with a shell so thin that the birds visited the branches and destroyed the nuts, necessitating the reversion of the process to make the shell of the right thickness; a walnut bred with no tannin in its meat, the coloring matter of the skin which has a disagreeable taste; a tree which grows more rapidly than any other tree ever known in the temperate zones of the world; the Shasta daisy, a blossom five to seven inches in diameter, made out of a wild field daisy, a Japanese and an English daisy; gladioli of greatly enhanced beauty, taught to bloom around their entire stem like a hyacinth instead of the old way, on one side; a dahlia with its disagreeable odor driven out and in its place the odor of the magnolia blossom; a calla with fragrance of the Parma violet, and a scentless verbena given the intensified fragrance of the trailing arbutus; a chestnut tree which bears nuts in eighteen months from time of seed-

planting; fruit trees which will withstand freezing in bud and flower; a poppy so increased in size that it measures ten inches across its brilliant bloom; an amaryllis bred up from two to three inches to nearly a foot in diameter; a calla increased in size until it measures ten to twelve inches in breadth, and then, the process being reversed, bred down to less than two inches; the white blackberry, a rare and beautiful fruit and as toothsome as beautiful; thousands of varieties of lilies. He has greatly improved the plums, pears, apples, cherries, grapes, quinces and peaches by selection and breeding; has developed many varieties of flowers, improving them in color, hardiness and yield; and has added much to the productiveness and edibility of vegetables. Pieplant with leaves four feet in diameter, bearing every day in the year; a prune three or four times larger than the ordinary French prune and greatly enriched; the pomato, an improvement on the poisonous potato ball, producing a rare fruit which grows upon the top of a potato; blackberries without thorns; the improved Australian star flower, one of the everlasting varieties which is to be used for

the decoration of ladies' hats; a larkspur greatly enlarged in size and given a delightful odor; many improved varieties of grasses; improved tobacco;—these are some of the works which have come from his hand; others to yield even far more important results are now under way.

To study more closely some of the wonderful achievements of this man is like opening successive doors into some strange vast castle where every apartment is the scene of a miracle.

CHAPTER III

THE CREATION OF NEW TREES

AMONG the thousands of people who visit Mr. Burbank's home from year to year are many who come out of idle curiosity, some who are prominent in scientific lines, whom he delights to welcome if they are sincere, some who come prepared to find fault and to overthrow, if possible, what has been built up. One day when there came a man who had been deeply interested in forestry, conversation fell upon the breeding of trees, the production of new and improved varieties of trees by means of cross-fertilization and selection.

The visitor had decided views upon the subject, and at once raised the question of the feasibility, even of the possibility, of any successful experimentation in tree-breeding, such as that Mr. Burbank had carried on in other plant life. In the first place, the experiments would need to be carried over through a series of generations, and, so slow the growth of the

trees, the man who began them would long have been dead before anything like important results would have been attained, thus largely eliminating continuity of effort and satisfactory personal supervision. Again, what was there to be gained in attempting to improve the trees of the world as they stand? And, again, there was the improbability of anything like satisfactory results in any fertilization—the whole scheme was interesting but speculative. Nor was there any practical bearing,—where could there be found any scientific value in the plan?

In all lines of Mr. Burbank's work the most satisfactory answer to the arguments of those who hold that, because such and such a thing has never yet been accomplished, therefore, it cannot be accomplished, is a fact. It was so in this instance. All that was necessary to do was to point to a single row of trees standing in front of his home at Santa Rosa, just outside the white fence that surrounds his grounds. They are noble trees, tall, wide-spreading, stately, pleasant to look upon, dignified and substantial as trees go, not weak or irresolute, possessing that indefinable attribute

which, even in trees, we call character. These trees answered every argument advanced. They were the result of breeding and selection; they had not been long in growing, not over a dozen years; they were economically important.

Some ten or fifteen years before, Mr. Burbank had studied the question of tree improvement with great care. All sides of the plant life of the world appeal to him. If he can see a chance for improvement, it matters not to him what the obstacles in the way or what the contentions of those who are chained to traditions. He had long seen a chance for marked improvement in certain varieties of the walnut. He took an English walnut and a common California black walnut, as types on which to work, crossed them by fertilization, raised seedlings from these, then selected the very best of the progeny; and so bred forward, ever picking out those which approached nearest his ideal until, at last, he had a set of hybrid seedlings which he was willing to trust to themselves.

A half dozen of the trees were set out in the hard earth in front of his house in the

street, where they would receive no cultivation and no irrigation in days of drought. They were left to shift for themselves. Fourteen years passed and, in 1905, the trees had become nearly eighty feet in height, their branch-spread was fully seventy-five feet, their trunks were fully two feet in diameter at the height of a man's head, and not much less than that at the point of the first branch, some twelve to fifteen feet above the ground. The wood is of fine grain, hard, very compact, having a lustrous, silky effect and taking a high polish. Sometimes the annual growth will be an inch or more, the successive layers giving to the sawn timber interesting and novel effects. The wood is suitable for furniture manufacture, for inside furnishings of houses, or for any place where open ornamental woodwork treatment is employed. For fuel the wood gives a steady, strong heat, combining comparative ease in cutting with the hardness essential for good burning.

Just across the street from Mr. Burbank's home stands another row of walnut trees. They have been growing thirty-one years, about twice as long as the ones on Mr. Burbank's side of

the road. They stand about twenty feet high, they are six or eight inches in trunk diameter. These trees belong to a past generation; the noble trees on his side of the road are of the progressive today. In fourteen years the new tree grew six times as much as the older tree had grown in thirty years. In addition to their specifically economic value, the new trees are very beautiful, making an ideal tree for shade in private grounds, for an avenue approaching some country estate, to over-arch in gothic strength some beautiful city street.

Along with the production of this tree which Mr. Burbank named the "Paradox" he worked on a different combination, though produced in the same way. The Paradox was particularly suited to regions like California, where winters are not severe. He wanted another tree, as rapid in growth, as fine for timber, as valuable for fuel, which would grow in any climate where the hardy northern black walnut would grow. So he joined together the native California black walnut and the old-fashioned New England black walnut, producing a new hybrid which he named the "Royal." This tree has answered all the demands made

upon it, and is fully equal to the Paradox. I recall seeing one of these Royal trees standing isolated in the front yard of a fruit ranch on the road to Sebastopol. It had been set out, a tiny sapling, at about the same time the trees were set out in the street in front of Mr. Burbank's home, and in the dozen years it had grown to magnificent proportions, completely dwarfing the other trees in the vicinity, even the large native live-oaks which are so conspicuous a feature of the northern California landscape. Each of the new walnuts grows in comely fashion, having no bad habits and readily yielding to the pruning-knife or to training, in case a branch shows any signs of ungraceful waywardness.

In a general way, the physical characteristics of each tree are quite like those of the other.

These trees have been bred for purely commercial ends, though they possess rare beauty as well. The nuts, at first, were not thought to have any special value, the object in the scheme of breeding being to develop the tree itself rather than its fruit, but, as the experiment progressed, it was found that certain of the seedlings produced fine hybrid walnuts,

different in form from the parent nuts and far more abundant, not a market nut though with a delightful flavor. The leaves upon the trees, as is noted in another chapter, are of many interesting varieties, and when rubbed in the fingers or crushed, or even when merely handled, give out a delightful fragrance somewhat like that of the apple, but as powerful and lasting as that of a rose or a lily.

But to come to the main life-plan of the new trees, it appears that they are in some ways the most important contribution Mr. Burbank has made to the specifically commercial life of the world. A simple computation will illustrate this,—the results are so remarkable as to challenge one's credulity, but they are results based solely upon facts, unadorned by any speculation.

Mr. Burbank says that for the best commercial purposes the trees of either variety should be set out not less than forty feet apart, in order to allow ample space for each. The root system is very extensive, and there must be plenty of room for each tree below ground, as well as large allowance for the spread of the branches. About thirty-six trees to the acre on

Walnut-leaf variation. To the left, common English walnut; to the right, the native California black walnut; in the center, the new hybrid "Paradox," bred from the other two.

suitable walnut soil should produce the best results. At the end of twelve years each tree will offer a clear trunk without branches which, when stripped of its outer slabs and squared, will be at least fifteen feet long by a foot and a half square. This will give three hundred feet of clear timber, board measure, per tree. Black walnut lumber has been steadily disappearing from the market. Year by year it has as steadily increased in price until it has now become one of the rare woods, running in cost from $200 per thousand feet, board measure, to $600 or $700 per thousand feet for particularly fine pieces.

Taking but $250 as the average price of black walnut lumber per thousand, certainly a conservative figure, at the end of the twelve-year period each tree is worth approximately $80. The acre yield would be $2,880. For an average farm of 160 acres the revenue for the twelve years, with no outlay save the cost of planting, not over twenty-five cents per tree, taxes upon the land, and interest upon money invested, would be a little over $460,000. This does not take into account the value of the branches, and the refuse slabs of the mill-saw-

ing, which for fuel would amount to at least four cords per tree — about $24,000 for the total farm, or a grand total for the 160 acres for lumber and fuel amounting to $485,000.

These figures seem absolutely preposterous, but it must be borne in mind that the trees are now to be seen growing at the end of a fourteen-year period, and that every item has been carefully verified; — hence the conclusion is legitimate, even if staggering. Naturally, should everybody go in for hybrid walnut raising, the price of this now rare lumber would be reduced, but, so valuable is it in so many ways,— for furniture, bank and office furnishings, dwelling interiors, for wainscoting and ceilings where costly woods are sought,— and so remarkable is it as a producer of wood for fuel, it is not at all likely that there would soon be a glut in the market.

In conversation with a practical manufacturer of lumber to whom this new work of Mr. Burbank was a revelation, he raised the point that, so far as his knowledge went, fast-growing trees were usually trees of soft grain which were not suitable for fine finishing. The strange fact is, however, that these new

trees have apparently defied all precedent,—they are not only of phenomenal rapidity of growth but they preserve all the hardness, tenacity and evenness of grain of their slow-growing ancestors. When I raised this point in conversation with Mr. Burbank, he sprang up from his chair in his characteristically energetic manner, was out of the room in a trice, and as swiftly returned from his repair-shop bearing a piece from a huge branch which had been cut off from one of the trees. It had been roughly squared by the workman and part of one side had been planed. The wood was unusually heavy to the hand, more like some dense tropic wood and very hard. It was of a beautiful color, the finish even by the plane alone showing its possibilities for taking a high polish. It will make a rare wood in its lighter color and will assume the darker walnut color when it is soaked for many months in water, as the black walnut is soaked before sawing in order to give it the peculiar dark hue. In point of fact, however, there are no doubt many who would prefer the lighter satiny tints to the darker. The heavy annual growth of the tree, forming such large layers,

adds another and distinctive note of interest to the grain of the finished wood.

In order to secure the opinion of practical men upon the new wood, samples were submitted to wood-workers, furniture finishers, carvers, painters, and merchant lumbermen. It was particularly interesting to note the expression upon the faces of these matter-of-fact men as they saw, the first of all industrialists to look upon it, this new factor in the manufacturing forces of the world. After the initial exclamation of wonderment, out would come a pocket rule, to measure the annular growth, each man seeming to doubt his own eyes. Then a sharp knife would be whipped out to test the wood for hardness; or, if it were a painter or finisher at work, brushes were at once dropped and a close and critical examination and test of the grain of the wood followed, volleys of questions being fired meanwhile.

Welding together many opinions expressed by these practical men, these statements may be taken as the consensus:

The production of a hard wood of the character of this at such a phenomenal rate of

growth would be considered an impossibility without the evidence of a man's own eyes.

The new wood is as hard as the old-fashioned black walnut, somewhat harder when fully seasoned.

It has a finer grain than the old walnut and takes a higher polish.

It is nearer the mahogany grades than any other walnut and remarkably like some of the tropic mahoganies.

Its possibilities when quartered or when sawn for other novel effects in veneers, are large.

The width of the annual growth makes it peculiarly suitable when sawn in long strips for wainscoting and like effects.

While the fiber of the wood is hard, it is fine for working as well as for polishing.

Nearly every man spoke of the possibilities of this new tree in rapidly re-foresting the earth, as well as of the fact that it would give a marked impetus to the use of hard wood for fuel, while marking what might be called a new era in manufacturing.

The trees of these two varieties which Mr. Burbank has produced have been given no

attention whatever. It is thought by cultivation and irrigation they would probably be led to produce as much timber in eight or ten years as they have done in fourteen years with no aid. The Paradox will grow in any climate similar to that of California, anywhere where the English walnut will grow; the Royal will grow anywhere in the United States, or any other country, where the hardy New England black walnut will grow.

The secret of these wonderful trees lies in the fact that Mr. Burbank selected them from the most rapid-growing of all the many thousands of seedlings he had under test, at the same time taking into account all the other characteristics that were essential. Enormous rapidity of growth, so to use the words, in the early life of the seedling has been maintained in after years so that these two trees now stand at the head — the most rapid-growing trees in the temperate zones of the globe.

They are deciduous, losing their leaves like the elm and maple in the late autumn.

In this, as in so many other lines of Mr. Burbank's investigations, a new field is now opened up for practical work. It now becomes

possible to produce trees at will for practically any purpose,—for ornamentation, for shade, for fuel, for manufacturing purposes; to breed together trees from widely separated quarters of the globe, each having some desirable characteristic the other has not, uniting the best of both in the child of the two, and then selecting and selecting through a series of years until the desired end is reached. Hardiness, longevity, rapidity of growth, symmetry of form, adaptability,—all play their part, all may be called upon to act at the proper moment. Mr. Burbank has given deep thought to this branch of breeding, realizing the vast importance to the world in any successful plan for maintaining and increasing its tree life. Upon this point he says:

"The possibilities of improvement in trees are so great as to make it seem almost an exaggeration to state them. Trees may be bred together within certain specific limits, to produce other trees of different character at will, combining the characters of the parents or developing wholly new ones. In human life pre-natal influences are marvelously powerful and extraordinarily diverse, and the spiritual

pre-natal influences are immeasurably more powerful than the physical ones. So that while the future no doubt holds much for the good of the race in the matter of an improved human stock, these influences are at present, at least, far too diverse and powerful to be mastered or even taken clearly into account. A single and apparently very slight thing may influence a whole human life, indeed, may influence many lives directly and indirectly through generations. Not so with a tree. Its life is more fixed and stable. It has been following the same influences and never departing to any extent from a given course for centuries upon centuries. It does not yield easily. It is stubborn, persistent, it must be pressed upon harder and harder.

"But when it yields, it yields unreservedly. Supply the right amount of pressure and the thing is done. Then, when its new life is fixed, it will persist in the new way as it has in the old. Take, for example, a tree which produces pitch, or maple-sugar, or tannin, or camphor, or quinine. Now if the ability of any one of these trees for producing its valuable product is fixed, but its capacity meager, this capacity

may be increased at will simply by breeding for this one trait and by selecting with this end constantly in view. Thus, a tree or a whole forest, for the principle covers all, may be bred to produce a vastly increased supply of any one of these commodities, double and treble its former amount, thereby becoming immensely more valuable. So in trees whose bark may be valuable for coloring matter, the coloring matter may be increased at will, making the tree that much more important from a commercial point of view. Any desirable attribute of a tree may be increased at will. There is work enough to be done in this line for the government to put at work a thousand experts, and the possibilities ahead of them are so great that the whole face of nature might be changed by them by an intelligent, patient and systematic following of breeding and selection.

"Take the line of producing trees upon which to graft others in order to hurry these others onward to quicker fruitage. For example, we will say a certain prune has very desirable qualities—it is high in sugar-content, large in size, admirable for curing and packing.

But it has an inadequate root service, and when it comes to bearing on its own stock, it soon exhausts itself and becomes unable to support the top; it gradually produces less and less and of a steadily deteriorating quality. What is to be done? Why, simply give it a new foundation upon which to build. The almond grows very rapidly, several times as fast as the prune. Graft the prune upon the almond when the almond has its root system established, say at five years of age, and let the almond do the hard work. See how the almond will send the prune bounding forward! It gives the prune its needed basic supply of food, and so the prune has nothing to do but to go onward, bearing abundantly.

"There are certain trees that are hustlers,—strong, vigorous, fast-growing, self-reliant, powerful to resist untoward circumstances. These must be made to help their weaker brethren, to give them better commercial qualities. Take it in the line of a walnut bred for fuel, to say nothing of lumber for manufacture. Suppose a man buys a walnut tree large enough to set out and pays fifty cents for it, and in ten years it will produce ten cords of wood

worth five dollars a cord—isn't the money well invested? Isn't it better to pay fifty cents for such a tree and get such results than to get another tree for nothing which in ten years will produce one cord? Suppose a man has a fine rich walnut or other nut which will produce ten times as many nuts when grafted upon a faster growing tree as it will produce upon its own roots—doesn't it pay to graft it?

"In considering the development of new kinds of trees and in improving old ones, it must always be borne in mind that no two trees are alike. Two trees may start out, for example, upon apparently precisely the same conditions, but one will grow a foot while the other is growing an inch. Oftentimes among a lot of seedlings one will grow from a hundred to five hundred times as much in a season as its comrade raised from precisely the same kind of seed. This fast-growing one is the one to choose, and by selection it may be developed still more until, as in the case of the walnut I have bred, it stands at the head of all trees in the temperate zones for rapidity of growth. Both this fast-growing seedling and its slower

comrade had the same chance, but one of them was a hustler and the other was not.

"The fact is too often lost sight of, or not known at all, that the tops of the trees absolutely govern the roots. The leaves are the lungs and the stomach of the tree. The food is digested, so to speak, in the leaves and there made accessible for the tree as a whole. If a tree be fine of foliage it will be powerful in all its parts, because it has the capacity to take so much nourishment from the air,—four-fifths of it being nitrogen, which is the chief source of supply for plant-food. The sun, too, plays its important part,—condensed sunshine and condensed air are the chief articles of the tree's diet.

"Each tree, too, has its own individual characteristics and traits, as well as being absolutely unlike all other trees in form and structure, and these traits must be studied and taken carefully into consideration. Take the one act of fruit-bearing. I find that in certain instances I have bred trees to bear too much fruit, the matter was overdone. It came about by constantly selecting from seedling trees which were heavy fruit-bearers, all the time

One of the hybrid chestnuts, bearing nuts at eighteen months of age from the seed

seeking to make even these increase. The result has been in some cases that I have had to go backward again to a point where the tree could produce its maximum of fruit without imperiling its efficiency.

"Bear in mind that, in the production of any new tree, selection plays the all-important part. First, one must get clearly in mind the kind of tree he wants, then breed and select to that end, always choosing through a series of years the trees which are approaching nearest the ideal, and rejecting all others.

"There is another important feature of a tree to be used for manufacture,—its grain. It is perfectly feasible to breed a tree up to a certain general style of grain, by constantly selecting for this special characteristic. As no two trees are absolutely alike on their exteriors, so it is with the interior of the tree. Cut open a series of cross-bred seedlings—some are dark, some are light, some are close-grained, some are coarse, some show tendencies toward beautiful markings, some are plain, some have wavy grain, some have straight. So pick out from them the grain you want, and continue selecting and breeding with

this stock as a basis; finally you have the perfected tree just as you wish it. Once produced, it is, save in minor essentials, unchanging. You can change the grain of the tree, or its bark, or its top, or its trunk, or its leaves, or its roots, or its quantity of quinine, or sugar, or pitch, or what not;—you can hardly think of anything you cannot do with it. You can make it grow tall or short, huge of girth or slender, narrow of branch or broad, you can change the number of leaves it will bear upon a branch and their shape. You can chemically transform it, too. Of course, the habits of the tree must first be firmly enough fixed through sufficient generations so that it will not revert—then it will go onward in its new course; or, by grafting, at once.

"There are certain things which do not seem possible, certain crosses of trees of widely separated species that seem out of the question. Still, while these crosses may never become what might be termed commercially effective, not practical, in other words, yet they may be what may be called scientifically successful. In other words, the actual act of crossing may be accomplished where it has

apparently been impossible. But this much may be done even in these remote cases:

"Two given species will not readily yield to union. Make a cross between them, take the seeds of the progeny and plant them. Cross two other diverse species in the same way and plant the seeds of their progeny. Then to the progeny of the first union unite the progeny of the second, and from this later union you may sometimes get marvelously satisfactory results. The outcome of either main cross would be unsatisfactory, perhaps unimportant; the union of their progeny may obviate the difficulty. The possibilities of such crossing and its subsequent selection are inconceivably great.

"It is my opinion that one of the most important, in some ways the most important of all the many fields open now to the plant-breeder, is this one of the production of new and the improving of old trees. I believe it to be of immense significance commercially."

Closely allied to this production of a tree is the improvement of the product of the tree, its nuts. Deciding that it would be well to have an English walnut with a thinner shell,

Mr. Burbank began a series of tests looking to that end by constantly selecting seedling trees whose nuts bore toward the point aimed at. They responded heartily to the demands made upon them, so readily, indeed, that one day the nuts were found so thin of shell the birds could pick through them. This required an absolutely opposite breeding, so the trees were bred backward again along the path they had come until just the required thickness of shell was reached. So it was also with almonds, the shell being bred to suit, while similar results may be reached with other nuts.

At the same time, general excellence and the question of productivity were under consideration constantly, with the result that a finer, larger and more prolific nut was produced. In line with what Mr. Burbank has done with grafting a physically insignificant tree upon a stronger one, a California nut-grower grafted Mr. Burbank's new soft-shelled English walnut upon a native black walnut of rapid growth. The average annual production of nuts per tree in the region had been from seventy to one hundred pounds. The black walnut tree, when grafted with this new

English walnut, produced on an average four hundred and fifty pounds of nuts per season, in some cases as high as five hundred and fifty-two pounds.

In the skin or outer layer of the meat of the walnut is more or less tannin, a substance which, when present in considerable quantities, relatively, gives the skin a dark appearance and makes the meat more or less bitter and disagreeable to the taste. In some wild nuts when it appears in larger quantities, it becomes positively dangerous. While the outside of the walnut is commercially changed by bleaching, the inside is not reached and the tannin has remained. Mr. Burbank thought that if Nature had allowed this undesirable substance to enter into the walnut, she could be induced to give it up, so he set about breeding the tannin out, succeeding at last in driving it entirely away, leaving the meat a pure creamy white. At the same time, he developed the size of the nut also, making it from a quarter to a third larger than its parents.

Turning his attention to the chestnut, he decided to relieve it of some of its bur, and

so by years of selection and breeding, the basis of all this work, he changed the thickness and the substance of the bur at will, finally demonstrating that, if necessary, the outer portion of the bur might be wholly done away with, leaving a smooth surface. To breed it too thin, however, would be undesirable, the bur being the nut's protection against birds.

The life character of the chestnut was also changed in marked degree. He set about producing a chestnut that would bear nuts early in life. Ordinarily it would be all the way from ten to twenty-five years before a chestnut tree raised from seed would begin to bear. Mr. Burbank decided that was altogether too slow for modern days, so he has made the chestnut bear nuts at the age of a year and a half; indeed, nuts have come upon trees not over seven months old.

In this way the commercial possibilities are suggested — where Nature does not move fast enough, she must be helped to more rapid progress.

From the standpoint of the adornment of the world, including with this that splendid sentiment which is becoming more and more

manifest, looking toward the preservation of forests and the rapid re-foresting of denuded areas, as well as from the purely economic point of view, looking to the creation of new types of trees better than the old and bringing the old up to a higher standard of efficiency, Mr. Burbank's work in tree-breeding is of commanding importance. In itself it is quite sufficient to have made the reputation of any plant-breeder in the world.

CHAPTER IV

THE AMARYLLIS AND THE POPPY

AMONG the thousands of letters which Mr. Burbank receives from all quarters of the globe are very many having unusual interest because of the prominence of the writers and because of their interest in the remarkable work of which they make inquiry, but he has seldom received one of such peculiar interest as that which came from a professor of a far eastern college. It told of the loss of a little son. In the depths of his great bereavement the father had sought for some memorial which should be a visible token of the rare life that had gone. So he chose one of the exquisitely beautiful amaryllis plants which Mr. Burbank had created, to plant upon the child's grave. The letter told of the splendid blossoms that came and of the deep satisfaction that such a monument had been chosen. The flower was of rare color and great size; it would be a lasting memorial.

He must be blind to all sense of color who is not deeply impressed by the brilliancy of these magnificent blossoms when seen in great masses. Through years of the most patient and painstaking labor Mr. Burbank has developed the amaryllis from a flower having a few inches of breadth until it is very nearly a foot in diameter and with every shade of crimson or pink or scarlet and many rare and unusual blendings, all the colors being greatly intensified. The usual methods of breeding and selecting were followed. It was found that the huge flowers were far too heavy for the ordinary amaryllis stem, so the complete transformation of the plant itself was planned. The stem was changed to meet the demands of the heavy flower, a low stout plant resulting, not more than eighteen inches high, with thick leaves and sturdy trunk. When a bed of these new amaryllis is in blossom it presents a spectacle of rare beauty, the great gorgeous blossoms illuminating the whole surroundings as with crimson flames.

Under ground even more wonderful changes have taken place. If you take two amaryllis bulbs, one of the old type, one of the new,

and place them side by side, you will see an even greater contrast than that which appears in the blossoms. The ordinary bulb will be two to three inches in diameter at the largest part and will weigh a pound or a little over. The new bulb is fully eight inches in diameter, twelve to fifteen inches in height and weighs from six to eight pounds. It is graceful in shape, having the form of a beautiful vase. In color it is like brownish copper with inner folds of silver.

But the most remarkable feature of the bulbs is their wonderful power of multiplication. In place of four or five bulbs, as in the old plant, the new amaryllis produces all the way from forty to fifty. When they were first introduced the bulbs sold at six dollars each, but by this rapid multiplication they will soon be produced so that they may be sold for a few cents each—then the poorest man may glorify his garden by these magnificent blossoms, and no one will be happier thereby than the generous-hearted man who has made them possible.

When Dr. Hugo de Vries, the great Dutch botanist, visited Mr. Burbank in the summer

of 1904, called to America mainly by his intense desire to see Mr. Burbank and to learn in person something of his work, he was deeply interested in the amaryllis experiments. He wrote an exhaustive article for a Dutch magazine comprising many thousands of words descriptive of his visit to Mr. Burbank,—further mention of which is elsewhere made,—and the following appears in regard to the amaryllis:

"Another example (of hybrids) is the amaryllis, which with us is a hothouse plant, but which, in California's beautiful climate, may be raised in the open. Thus it is made possible to bring to flowering tens of thousands of seedlings, while in Europe we can select only from a few hundreds. In such a ratio as this, the number of years necessary to bring about as great improvements is much less. It required more than half a century to get the amaryllis with their large flowers neatly closed in with their numberless shades and stripes which we admire so much. Burbank, of course, is able to hasten the process.

"Years ago, when the improvement of fruit trees almost exclusively drew his attention, he

raised and crossed the amaryllis, but only for curiosity's sake and on a small scale. But soon the results promised that more labor and expense bestowed upon them would in the end be well rewarded. Then he commenced the development more systematically and turned his attention to the propagation of very decided properties,—larger flowers, but, especially, more flowers on the same stem, and next to that, all those characteristics which would give more rapid development and a larger reproductive power. Some bulbs which, when starting the experiment, produced only five or six bulbs, were forced by crossing with more fertile species and a careful selection to double the number of bulbs, while at the same time, the bulbs were increased in size and threw out stronger stems and fuller flowers.

"But what was the most remarkable was the shortening of the duration of life, from seed to seed, as it is called. I mean the number of years which a seedling requires before it blossoms and produces seed. It is clear how much this includes. If after every crossing there elapse four or five years before the result may be judged by the one flower, all that time

A bed of the hybrid poppies

must be given to its care and cultivation, but by the use of the first flowering seedlings in crossing, the duration of life from seed to seed is cut in two, so that after two or three years new crossings will be ready for him to pass judgment upon them. Almost all of the long California summer we may now have the amaryllis in flower. The flowers reach a diameter of twenty to twenty-five centimeters in different varieties, with flower leaves overlapping one another with their broad edges. The colors and figures compare with the best European kinds, while a strong-built plant, an easy handling and rapid multiplication make it a very desirable garden plant. It is the aim to make it one of the most common plants which will find its place in parks and at summer resorts, in city gardens and around the farmer's dwelling.

"Endeavors to cross the amaryllis with the related Crinums are started, and from what I saw of them, the first trials were crowned with success. The *Crinum Americanum* is a wild plant from the Florida swamps which proved its fitness for crossing. At the same time a number of other species were raised for the

same purpose (of crossing). These were more tender and came from more tropical regions. Some, Burbank was even obliged to keep in his hothouse, but, when crossed with the garden amaryllis, they gave hybrids which felt at home in the California climate."

De Vries, in concluding this part of his comment, again referred to the means which Mr. Burbank has made use of to shorten the duration of life from seed to seed, noting that "many a tree or shrub with us (in Europe) only commences blossoming when it is ten or fifteen years old," a great obstacle especially when repeated crossings are necessary. He then calls attention to the means which Mr. Burbank has utilized, threefold in character:

"The selection of California, with its beautiful climate; the selection of the first flowering seedlings, and his method of grafting."

He then describes Mr. Burbank's method of hurrying hybrids forward with great rapidity by grafting upon a vast scale, as elsewhere described.

Down through long rows of green beds where plants of many kinds are under test, showing in the gradations from the small,

weak ones up to the strong and large growths the endless marvel of selection, the eye wanders, meeting a novelty at every foot until, at last, it rests upon a plot of ground perhaps fifty feet square wherein are growing two thousand of the most marvelous plants that ever were seen since the world began. This plot or bed of ground contains the new hybrid poppies upon which Mr. Burbank has been working for many years. The chief crosses have been between the oriental poppy, *Papaver orientale*, a perennial, and the opium poppy, *Papaver somniferum*, a short-lived annual. Out of these crosses came the bed of poppies, no two of the whole two thousand alike. In the foliage especially, and also in the blossoms to a lesser extent, nearly every order of plants known appears. The leaves are a source of intense interest as a study for a botanist or plant-breeder, presenting remarkable combinations of old forms with production of entirely new ones.

The object of making this great crossing was far more than reached—the results were richer than could have been expected. Scientifically interesting in a marked degree as

it was,— some of the plants bearing great quantities of seeds but no flowers, some bearing beautiful flowers in great profusion but not a single seed, some bearing seeds and flowers arranged in the most fantastic shapes with flowers surrounding the seed-capsules and *vice versa*, and some curious ones bearing neither seeds nor flowers,— yet the experiment proved still more interesting to the layman from the point of view of the adornment of the world. For among all the wonderful improvements in floral life which Mr. Burbank has effected, it is doubtful if any one of them has shown what might be termed such spectacular beauty. His creations are each so individually characteristic and beautiful that they are not easily to be compared, but the poppy results certainly may be designated as among the most magnificent.

But look a little later upon this bed of poppies, and even the strangeness of the new life in seed-capsule and leaf is overshadowed in interest by the splendid blossoms themselves. They are now a mass of crimson and black and white, with many intermediate blendings. So huge the blossoms, so wide

the mass of color, it is as though some great painter of the world itself had stopped on his way over this fair valley, forgetful of the rest of the earth, and here had fairly exhausted his brush. The blossoms are from eight to ten inches in diameter. Place seven of them side by side in a vertical row, they are as tall as a tall man,—eight of them measure the height of a giant. A man could hide behind a dozen. Individually, the flowers have all the beauty of their ancestors, only enhanced. Effective in interior house adornment, taken in the mass out-of-doors, they present magnificent decorative possibilities. All this is made still more significant because of the fact that most of the new species are perpetual bloomers, lasting throughout the entire season instead of two or three weeks at the outside, as is the case of other poppies. They are perennials, also.

With this new poppy a commanding figure enters upon floral life.

Something of the remarkable character of the work which Mr. Burbank does is seen in his ability to take a single one of these new poppy seed-capsules, divide it into four sec-

tions and, by pollinating each section, produce from one section an annual plant, from another a perennial, from the third quarter crimson poppies, from the fourth, white ones. In another experiment Mr. Burbank has produced a blue poppy, a blossom unknown to the world before.

Strangely interesting, also, is a new poppy now under process of development, which promises to become a notable addition to this varied family. It is the result of the union of the *Papaver pilosum*, and the *Papaver somniferum* of the variety known as the "Bride" poppy. The first named is a delicate flower, the general color being a dull orange, with white center. The second is pure white, the seed-capsule in the center a shade of green. The first one has smooth-edged petals, the white one heavily laciniated ones. The child of the two is a fire-red or scarlet with purple at the base of the petals, a most striking flower. It has rejected the smooth edges of one parent and adopted the irregular laciniations, or fringe, of the white parent. The divisions of the fringe of the new poppy are wider than those of the parent, though the

The central poppy, a brilliant scarlet with purple center, is the offspring of the other two. The one to the left, *Papaver pilosum*, a delicate orange; the one to the right, *Papaver somniferum*, the "Bride poppy," a pure white. Leaves of each are shown.

incisions are not so deep. Its foliage is wholly different from that of either parent. The Pilosum is of solid color throughout its petals, as is the other parent, the offspring presenting a combination of purple and scarlet as noted.

As one studies more into this line of his experimentation, the wonder grows steadily,—the possibilities of what he may yet accomplish in this one branch seem limitless; for, aside from the production of the strange forms which appear in the foliage of the new poppies, and the development of the great poppy itself which stands apart among flowers, he has done what might well be called the impossible: he has changed the native California poppy from gold to crimson. Many acts has this man done which savor of the miraculous, none more marvelous than this. Once, when he was looking over a field of these gorgeous flowers that cover the California hills and roadsides in the early summer as with a splendid mantle of gold, he discovered one blossom which bore a faint trace of crimson, a slender line along down its yellow satin chalice. It was a strange stain of Nature. She had done her work well to place this odd

note of color where it would fall under the eye of the man who has scrutinized her as others have never done. Instantly he isolated the plant, transplanted it, watched it with jealous care. Its seeds were saved and planted. Some of the flowers which came upon the plants from these seeds showed a similar line of red slightly widened. Again the crop of seeds from these new plants, now much more numerous, was planted, and a far larger harvest of blossoms was produced. Some of them were true to their ancestral forms of life and nodded their pure yellow heads in saucy defiance. They paid sadly for their temerity, for all of them were rejected. Others had still more pronounced hints of the crimson, and these were selected for further planting. So on and on the test went for years, each successive generation showing stronger tendencies toward the end desired, as the petals grew more and more crimson. At last the end was reached, the yellow poppy had become a deep lustrous red; it was hard by the land of miracles.

From certain quarters, — so curious the inconsistency of man,—came up more or less

violent protests against this act,—the golden poppy, was it not the adopted flower of the state of gold? And here was this worker of miracles changing it to crimson and robbing the state of its most distinctive and characteristic adornment! But Mr. Burbank met the protest with a gentle smile, and the poppies go on their gorgeous way embossing the California hillsides, gold upon green in high relief, like the ornaments of some mighty shield, while the crimson poppy which has been so gently stolen from their midst is returned to the world again for the adornment of the gardens of many lands.

Many other striking varieties are developing in the midst of all the crossings thus secured, exhibiting all manner of combinations of crimson and gold.

But Mr. Burbank does not attempt the enlargement of a flower just for the sake of making it bigger than some other flower, or even that it may be called bigger than any of its ancestors. Bigness, as such, has no champion in him. He makes a flower larger than its ancestors when that flower has certain characteristics which make increased size

desirable. A lesser man might, with the same power in his hands, breed flowers merely to be huge without regard to the flower's plan in nature or the fitness of things. Not so with Mr. Burbank. He has as great a delight in intensifying the color or deepening the fragrance of a violet as he has in making some flower with distinct decorative possibilities more noble of bloom. He might, through years of selection, produce, no doubt, a violet much larger in size then any now known, but he would as soon think of preserving some ugly monstrosity of plant life as of thus disturbing the life habit of one of the most exquisite of flowers. Deeper tones to the violet, yes; greater luxuriance of growth, wider zones of cultivation, greater hardiness, intenser even if subtler perfume, yes; but abnormality, never.

The whole scheme of his treatment of floral life embraces harmony and symmetry. He would round it out when it is angular, make it more graceful when it is awkward, deepen and vary its fragrancies without making them oppressive. No man who has ever lived has laid out such a scheme for the adornment of the world, indeed it may fairly

be stated that no hundred plant-breeders who have preceded him have ever done so much to ennoble floral life. And the future holds possibilities to be still more clearly indicated when his new creations, many of which are but just coming into general use, shall be universal. Years have been necessary in his tests to bring the flowers up to their high estate, and years more will elapse before all the tests under way will be completed, but enough has already been done to alter the whole floral life of the world. Those who were fortunate enough to see the magnificent display of cannas at the Pan-American Exposition in the city of Buffalo,— the "Tarrytown" canna, one of Mr. Burbank's creations,— could form some idea of the grander possibilities of his new flowers; and at the exposition in St. Louis the first prize for bedding roses, a rose which has limitless possibilities for exterior decoration, was a rose created by Mr. Burbank. But the more magnificent creations are not more wonderful, or more important, than those which have their culmination in his glorification of the tiniest blossoms, be they those shy wild ones which open their eyes in

the depths of the cool dark forest, or those more daring ones that witchingly display their dainty brilliancy in the gardens of the town.

It is his close and intimate touch with nature, united with his keen sense of the fitness of things ever manifest in all he does, that enables him to deal with these flowers quite as a painter with his landscape. He makes them not only in a certain beautiful sense interpret his own thoughts, giving to the world in the completed whole that which he has long been planning in his own brain, but he fits them unerringly into their natural place. It is, if you will, the blending of the artisan and the artist.

CHAPTER V

THE POTATO AND THE POMATO

DIRECTLY in line with many of what may be called the commercial achievements of Mr. Burbank,—though these are no less wonderful than those which have had a more æsthetic bearing,—is his work in the production of the potato. It was this vegetable, as has elsewhere been noted, which originally brought Mr. Burbank's name into prominence, and all through the years that have intervened since its creation it has had a large influence not only upon the wealth of the nations but upon the dietary of the people of many countries. Recent reports from Ireland show that the Burbank potato bids fair to redeem that long-distressed island from famine, because of its ability to withstand the diseases which have destroyed other varieties.

For many years Mr. Burbank has been at work upon new varieties of potatoes. Even though the one that bears his name has

proven so successful, he has not hesitated to set about producing improved ones, the possibilities of the potato for doing better and still better service to the world being unusually pronounced. With this end in view, he has gathered varieties, both wild and tame, from many different countries, making from them a bewildering number of crosses and combinations. Some of them are curious in character, as, for example, the snake potato, a crescent-shaped type from South America about three inches long and a little over half an inch thick in its largest part. The wild potato from Arizona has a most peculiar form. One would never believe it to be a potato. In shape and general appearance it is a large-sized raisin. Some of the potatoes of this variety are dark reddish brown, some lighter, but most of them have the distinctive shrunken look and shape of the raisin.

Such wild potatoes as this form valuable adjuncts to the work. Very often a wild strain of blood supplies Mr. Burbank just the needed element to make a weak race powerful. It was Emerson, whom Mr. Burbank most delights to quote, who said one day on this point:

Wild Arizona potatoes used in breeding to give strength and hardiness to the common potato

"The city is recruited from the country. In the year 1805, it is said, every legitimate monarch in Europe was imbecile. The city would have died out, rotted and exploded, long ago but that it was reinforced from the fields. It is only country that came to town day before yesterday, that is city and court today."

Some of the potatoes which are hurried forward in the greenhouse are very interesting because of their size. Perhaps a hundred of them, so small are they, may be held in a child's hand, and all of them perfect potatoes and all differing in color, size and shape. One new potato which has proven most toothsome is beautifully colored throughout all its flesh. The color is a magenta approaching crimson, so distributed that, when the potato is cut open, no matter from what angle, it presents most interesting figures, some conventional, some severely geometric, some having a startling likeness to human and animal faces.

Mr. Burbank says that an erroneous opinion prevails that the potato has a tendency to die out, or run out, as the phrase is, in various countries. He says this apparent running out of a given variety is generally due to the intro-

duction of better varieties which slowly but surely supplant the old ones. He makes note of the fact, too, that the seed-ball of the potato is less and less often found now upon the common varieties, due to the fact that the tuber of the potato itself is used in planting exclusively. The continued disuse of any organ in a plant, as in an animal, tends to its weakening and final extinction. He notes among plants which have gradually passed through the same experience the sugar-cane, banana, horse-radish, sweet potato and others.

Thousands of new potatoes are being bred by Mr. Burbank in the midst of his new tests in the search for better stock. Very much of this is begun in the hothouse, in order to save time. Selection here goes on upon an elaborate scale, but, important as it always is in this production of plants specifically valuable commercially as well as those for adornment alone, selection is not less important, in a commercial production, than a knowledge of the needs of the various parts of the world to which the new production is to go. Here lie some of the most important problems in all Mr. Burbank's work, the solution calling for the widest pos-

sible knowledge. He studies a thousand and one phases of the subject whenever he projects a new creation. He must know the conditions under which old varieties have been produced and their life history; he must know the character of the soil, the length of season, the climatic conditions, the markets, and their demands. He never produces a new fruit or vegetable without taking clearly into account all these practical bearings. This adds enormously to the sum of all his labor, but it is precisely this which has made his creations so successful — he knows not only how to create but how to fit and adapt. This suggests something of the tremendous demands made upon Mr. Burbank in the prosecution of a work of such great magnitude and of so diverse a character.

So these new potatoes are being bred to suit all sorts of climate and soils.

But there is another and vitally important phase of the work, the changing of the potato itself — making it over into a far richer vegetable than it has ever been before. Just as corn may be bred, and is being bred, to produce a required per cent of a given element, so

a potato may be bred to increase or decrease its chief characters. The average potato is composed of about seventy-five per cent water and twenty-five per cent dry matter. This latter is, broadly speaking, composed of starch, protein and fat; though these two latter elements are present in but small quantities, the main body of the dry matter being the starch. In the growing potato vine there is a very large proportion of starch, larger than either rice or corn, approximately eighty per cent.

Before considering the immediate plans of Mr. Burbank in the improvement of the potato as a table food, it will be of interest to show something of the practical bearing of his work upon the manufacturing possibilities of the potato in the line of starch. The seventy-five per cent of the potato which consists of water may, from the manufacturing point of view, be considered as largely waste, or, if not waste, at least of no commercial value. Very much of this waste may be restored, negatively speaking, by driving out the water and putting starch in its place. Mr. Burbank's investigations have shown that it is

as easy to breed potatoes for a larger amount of starch as it is to breed for any other characteristic — flavor, resistance to disease, withstanding drought, adaptability to a given climate, early or late maturing, and so on.

If in his experiments he develops a potato which has twenty-five per cent more starch than the normal potato,— though even a larger amount is possible,— the result is of marked importance from the point of view of the manufacturer. The value of the average annual production of potatoes in the United States is now, approximately, one hundred millions of dollars. In round numbers the United States produces each year about ten million dollars' worth of starch. The chief sources of supply for this starch are Indian corn and potatoes. Of the four main uses to which starch is put,— for the laundry, for the manufacture of glucose, for edible purposes, and for use in the textile arts,—corn, in the United States, supplies the main portion of the first two. In Europe the potato is practically the main source of starch supply. Potato starch is of much importance to the manufacturer of cottons, woolens, silks and

linens, as sizing for the warp before it is woven; for finishing the goods after they have been woven, bleached and dyed, and, in the form of dextrine, as a thickener or vehicle for applying the colors to a fabric. The dextrine, or British gum, is used a great deal also in the manufacturing of mucilages.

But the potatoes in use for starch manufacture in the United States are very often poor in quality, made up of culls, immature tubers, or those injured in digging and sold as waste. The starch is quite likely also to be low in grade and lacking in uniformity, greatly varying from day to day. Still, notwithstanding this, for use in textile arts, the potato starch commands nearly double the price of corn starch.

Attempts have been made to increase the supply of starch by the use of fertilizers, but Mr. Burbank's plan is better than this, for it begins with the source of the supply itself and works directly upon the starch in the plant, as is the case in the breeding of corn for a larger starch-content. The potatoes which show a somewhat larger amount of starch are selected for further testing, and here again the supreme

importance of selection is shown, each succeeding generation having an increase of the desired characteristic over the former.

Nearly twelve millions of dollars are invested in the United States alone in the manufacture of starch. With twenty-five per cent of starch-content added to a given thousand pounds of potatoes, there being no attendant increase in the cost of manufacture, the economic importance of breeding for starch becomes apparent. In Europe the matter has received much attention, and efforts have been made to increase the amount of starch. Along with the increase in starch supply which Mr. Burbank makes available for the whole world simply by an intelligent following of the lines he has laid down, comes increase in productivity, for he is able to unite these two characteristics in the same plant.

In the production of alcohol for manufacturing purposes the potato is coming more and more into favor. The starch is converted into maltose by the diastase of malt, the maltose being easily acted upon by ferment for the actual production of the alcohol. An increase

in the starch-content of the potato for this manufacture is particularly desirable.

But important as this breeding of potatoes is from a manufacturing point of view, it is still more important as a means of food supply. The great value of the potato as a food lies in its being a concentrated food, supplying both heat and energy, though needing the foods rich in protein to make up a model balanced ration. Mr. Burbank is now making over the potato. He long ago saw its possibilities, and only the tremendous demands of other experiments upon him have prevented the completion of the work. He will leave the potato, when he is done with it, a far more important feature of the world's supply of food than it has ever been before. Already enough has been accomplished in the preliminary test, to foreshadow the end. He has had four main objects in view in the work: A potato with a better flavor, one with a relatively larger amount of sugar, one that will be of a larger size and all of the same uniform shape and size, and one that will better resist disease and be a larger yielder than any potato now known.

Potatoes growing upon a tomato vine after grafting upon the potato root

While he is working with all these factors in view, and gradually bringing the potatoes under test up to the standard he has set for each, he is perhaps more deeply interested in the production of a better flavored potato than in almost any of the other features, important though they are. He holds that it is highly important in the production of a new fruit or vegetable to make it preëminently palatable, for, in the last analysis, it is palatability that decides the permanence of any new food. If palatability be eliminated as a factor, then mankind is prone to consider the food,—no matter what its form or character,—a medicine, to be taken because it produces certain necessary results. He has long been working, and with satisfactory results, to breed more sugar into the potato as one element of palatability so that when cooked it will present a far more satisfactory flavor. Several of the new varieties now under test have already shown a delightful advance in this respect over older varieties. The question of size is also important, and Mr. Burbank is giving to the potatoes uniformity so that they will be more satisfactory for shipping. The old-fashioned

potatoes varied much in a given hill, rendering them unsatisfactory for marketing without selection. Mr. Burbank will obviate this by making them all practically of the same size. Uniformity will also be more satisfactory for cooking purposes.

While the potato and the tomato are very closely allied in family ties, being, indeed, not far separated blood relation, they are as far apart as the poles when it comes to any satisfactory amalgamation. Mr. Burbank has found many similarly strange instances where two plants which, by all the probabilities, should be the very ones to be most hospitable to each other, utterly refuse to join.

But some very remarkable results developed in his attempts to cross the two. For example, he has produced tomatoes from the seeds of plants pollinated from potato pollen only. He has produced what he has aptly called "aërial potatoes," most peculiar in form, growing on a Burbank potato vine grafted on a Ponderosa tomato plant. These open-air potatoes are of many different shapes and sizes, as well as colors. Some of them assume grotesque forms and appear quite like little pigs.

Reversing this act, he grafted the same kind of tomato plant upon the same kind of potato plant and produced, underground, a strange-looking potato with marked tomato characteristics. Two distinct species of tomatoes were crossed, producing an exceedingly interesting ornamental plant about twelve inches high by fifteen inches across. It has remarkably attractive and unusual leaves and compact clusters of uniform globular fruit, the whole presenting a unique appearance. In this connection Mr. Burbank suggests the possibilities for the development of the tomato on the part of amateur and commercial plant breeders—opportunities for the developing of tomatoes with greater nutrition, more palatable, and with better keeping and canning qualities being pronounced. He looks upon the tomato as a desirable vegetable as it stands, but as one which by no manner of means has been brought up to its proper plane.

But important as is the work of Mr. Burbank in potato culture, both in the production of the world-famous potato which bears his name and in the large tests now under way in

the transformation of this vegetable, it appears probable that it will be rivaled, even if it is not surpassed, by the new fruit which grows upon the potato which he has named the "pomato." Among all his many interesting and novel creations this certainly takes high rank, not only for its novelty but for its practical value. Looking to the common origin of the tomato and the potato, and considering the general appearance of the new fruit, he has happily combined the two names in designating this new creation.

The pomato is a fruit, not a vegetable, though growing upon a vegetable. It is what might be termed the evolution of a potato seed-ball. It first appears as a tiny green ball upon the potato top, and develops as the season progresses into a fruit the size and general shape of a small tomato. The flesh is white, bearing, usually, a few small seeds. It is delightful to the taste, having the suggestion of quite a number of different fruits and yet not easily identified as any particular one. It may be eaten either raw or cooked. It is fine eaten raw out of hand, delicious when cooked, and excellent as a preserve.

Aërial potatoes growing upon a potato cion grafted upon a tomato plant

CHAPTER VI

THE LILIES

SURELY, since the world began, Nature never presented a stranger spectacle than that seen several years ago on Mr. Burbank's proving grounds at Sebastopol, when a hundred thousand seedling hybrid lilies were in blossom at the same time. And never before did so vast a volume of perfume,—there is no other figure to express it,—rise toward the summer sky. So intense was the fragrance that ranchmen a mile away could distinctly detect it, while all the country round about and the little town that lies at the entrance to this wondrous place was saturated with the odor. It was a strange composite fragrance, too, a thousand scents blended into one; for with the tens upon tens of thousands of different lilies came not only a well-nigh infinite variety of flower, but an indescribably rare and complex odor unlike anything the world had known before.

A visitor to the lily-testing grounds at Sebastopol, Mr. Charles Howard Shinn, in a newspaper article printed at the time, spoke thus of the general effect:

"This great mass of a hundred thousand lilies in full bloom, on a California hillside, in mid-June, surrounded by orchards, wheat fields and fringes of forest, is peculiarly enchanting. As one approaches, the golden, orange and red tints which predominate, mingled with various shades of green, produce the effect of some huge product of Oriental looms. Little by little, as one draws closer, the colors separate, and widely diverse types of flowers are seen to be growing side by side. One finds lily stems varying in height from six inches to nine feet, all bearing open flowers. Some plants have many stems, others but one, and a few present stems with distinct branches like the branches of a tree. Flowers, leaves, stems and roots show every conceivable variation. The biologist would find material for a volume in this lily field.

"Some lilies have but one petal, rolled like a cigar and half-open like the broader end of a cypripedium. Others have two petals spread-

ing apart like wings. Others, again, have three or four or five petals. The great bulk, however, have the normal six. The variation in color is extreme, ranging from white to dark purple, through surprising changes of combinations. The methods of growth are equally curious. Many stems bear all the flowers at the top, almost level, a new system for lilies, and especially useful in garden grouping. One such plant two and a half feet high carries fifty-six flowers. A tall spike of golden brown lilies, of *L. Humboldtii* type, carries ninety-one flowers and is four feet high.

"In form, size, color, fragrance, this field of hybridized lily flowers is a revelation. There is certainly nothing like it elsewhere in America, and I do not know of any place in Europe where such a collection can be found. We came out of the field yellow and brown from head to foot with lily pollen."

Comparatively little had been done by any one to treat lily culture in a broad manner, until Mr. Burbank took it up;—certainly no one had ever attempted it upon such a gigantic scale as this. The lily was recognized as an exceedingly difficult plant upon which to

work, and, while possibilities were admitted, it was shunned because of the obstacles in the way. Many had pronounced it incapable of any satisfactory hybridization. To one of Mr. Burbank's temperament the very fact that possibilities were promised in the face of difficulties made the outlook all the more attractive; for he had found that in nature, as well as in all departments of endeavor, the things which are most easy of accomplishment quite often are the least desirable; those which are the most difficult, the ones which yield the most important results.

But here, as in so many departments, he had a distinct and commanding advantage over all others in the magnitude of the work. He had also the advantage of a superb climate and soil where lilies from different zones could meet upon a common congenial plane and where each one would be at its best. The lilies showed an unusual tendency to depart from their former life habits. Sports or abnormalities were very common. Some of them were valueless, save as curious testimonials to the eccentricities of Nature when her life forces are disturbed and have not yet

had time to adjust themselves; some had distinct value in the promise they made of greater things. Such as had a prophecy of some new and desirable trait,—added vigor, greater hardiness, adaptability, unusual form, or great beauty,—were preserved, and work upon them has steadily progressed.

Nearly fifty different kinds of lilies were chosen from widely separated parts of the world. These were planted, and from the blossoms elaborate crossings by pollination were made through a series of years. The work was mainly done by means of the finger-tips, with a watch-crystal or small saucer to hold the pollen. It was what might be called pollination by wholesale; it had never been equaled in extent before. For several years this work proceeded, until Mr. Burbank was planting several pounds of seed per year. At last there were enough plants to begin the great test, and a hundred thousand of them were transplanted to the proving grounds at Sebastopol. Here they occupied two acres of ground.

In the carrying forward of the work more than a million lily bulbs had been produced

up to this time, and a vast number have since been grown.

In strangeness of form these lilies rivaled anything Mr. Burbank has ever produced. For example, one seedling from a native wild California lily which grows only ten inches high produced all the way from twenty to forty blossoms on each of the short stalks put forth, whereas the usual number was from three to eight. One small dwarf lily, the result of a cross, bore twenty-eight flowers; while another, a branching lily with eight stems coming from one bulb, bore over two hundred buds and flowers. One plant of this cross showed thirty-seven stems.

Speaking of the curiously interesting variations in flower, plant and bulb, Mr. Burbank says:

"One blossom is white; another pale straw or creamy white with thick recurving, channeled petals, studded with numerous papillæ with light yellow anthers; another is perfectly green throughout in appearance, very much resembling a trillium in form and general character; some are tigridia-like; others open their petals in such curious

manner that the flowers resemble sprekelias in form; some are crimson or yellow or darkest orange-yellow, with leopard spots or plain. Many grow six to eight feet high, others only six to eight inches. About one-fifth are fragrant, some slightly, others powerfully so. Some bear only two or three flowers to each stalk, while others have twenty to fifty or more. The leaves are broad or narrow, long or short, light green or dark green, and some beautifully striped with white. Some varieties have branching stems.

"The bulbs are almost as much of a study as the flowers. Some have flat, thin, open scales like a rose or clematis flower; others have close, thick, incurved scales, some many-jointed, others entire and some crenated; a few with pink or red bulbs,—but oftener yellow, orange or white—some of them being nearly globular, others conical or flat. Some throw out numerous long moniliform, underground runners. Some varieties have a tendency to start early, others late."

The calla was bred for larger size, combined with strength of stalk and great beauty, a blossom being produced at last nearly a foot

across on a stem six and one-half feet high. Per contra, a perfect calla was made not more than an inch and a half in diameter and perfect in every detail.

Another calla was bred having handsome golden variegated leaves, in interesting contrast with the leaves which formerly had borne white spots. Before this great work, the common garden calla had had no odor, or, at best, only a faint and rather disagreeable one. As Mr. Burbank was examining a series of calla seedlings, he detected one which bore a fragrance with the hint of violets and the suggestion, too, of the water-lily. This calla was isolated and bred for its perfume. Rigid selection and exclusion followed, and little by little the perfume was increased and intensified until at last it was fixed, a rare and delightful attribute. The new flower also grew in marked profusion, and blossomed earlier than the calla from which it has been bred, the most constant and abundant of all callas. Mr. Burbank says:

"Twenty-six years ago I began to cross our native Pacific Coast lilies, adding from time to time all the exotic species and varieties

A rare two-petaled hybrid seedling lily

which seemed to promise favorable results, until my collection was the most extensive in the world. These have been combined and selected, and recombined and reselected, until the most important results ever achieved among lilies are now an embodied fact. Of some of the older hybrids and seedlings I have as many as a thousand bulbs of each variety and have also half a million kinds yet to unfold their petals for the first time, and am still planting from one to three pounds of hybridized lily seed every season. The best of the world's lily experts who visited my grounds decided that there were at least two hundred and fifty thousand lilies which were distinct hybrids among the millions of lilies then blooming on my grounds.

"Can my thoughts be imagined, after so many years of patient care and labor, as, walking among them on a dewy morning, I look upon these new forms of beauty, on which other eyes have never gazed? Here a plant six feet high with bright yellow flowers, beside it one only six inches high with darkest red flowers, and, further on, one of pale straw, or snowy white, or with curious dots and shad-

ings; some deliciously fragrant, others faintly so; some with upright, others with nodding flowers; some with dark green, woolly leaves in whorls, or with polished, light green, lance-like, scattered leaves.

"As the fresh, dew-laden petals of these new creations, which had never been spread out to the light of day, were unrolled before me, a new world of beauty seemed to have been found and a full recompense for all the care bestowed upon them.

"The bulbs are a study, and had not some of them been in value ten times greater than their weight in gold, photographs would have been obtained to show their peculiar forms. Nearly all these new lilies are crosses from parent species selected for vigor, hardiness, easy management and rapid multiplication, as well as fragrance, beauty of coloring, grace and abundance of flowers. In these hybrids a broad foundation has been laid for endless variations which will reward lovers of flowers for ages to come."

The development of the various lilies is going on under Mr. Burbank's direction upon a still more extensive scale.

CHAPTER VII

PLUMS AND PRUNES

IT would be difficult to reach a satisfactory estimate of the amount Mr. Burbank's commercial creations have already added to the world's wealth. This is particularly difficult both because of the rapid progression of a new fruit through multiplication in different lands, replacing old fruits of its kind season by season, and because of the large number of varieties in his list, each one filling a separate field. For example, he has introduced over twenty varieties of plums and prunes, each with some distinctive and valuable characteristic, while he has made several thousand new plum and prune combinations, many of which are now under test. The potato which bears his name has increased the wealth of the United States by many millions of dollars, but the new plums and prunes promise to exert a still wider commercial and economic influence. One entire town in California,

for example, has been built up very largely upon one or two of his plums. The plums introduced by a few trees in a region which was by nature and climate suited to them rapidly increased as growers saw their good points, until they became the center of a packing and shipping industry employing thousands of people in the growing and preparation of the fruit.

Something of the wide-reaching influence of the new plums is seen in the fact that several of them are now being extensively cultivated on the island of Borneo, supplanting largely the native fruits of this type and promising to revolutionize the fruit culture of the island. They are also shipped from Borneo to surrounding countries. The late Cecil Rhodes became so much interested in the work of Mr. Burbank that he ordered all his new fruits for his extensive fruit ranch near Cape Town. One day several years afterward, a consignment of the plums which grew from these cuttings was shipped 18,000 miles by steamer and rail from Cape Town to San Francisco, as a test, arriving after their long journey in prime condition. From many

other points, particularly in Europe, have come testimonials from those who have introduced various of Mr. Burbank's plums, all the more significant because the stock was bought not of him but of some dealer to whom in other years Mr. Burbank had sold the original stock. His letter files are full of the heartiest thanks from American fruit-raisers for having made plums and prunes which have very greatly increased their revenues. One man enumerated the following points about a plum he had bought of Mr. Burbank, and his estimate of the fruit may be taken as the condensation of hundreds of letters: 1. A more rapid grower. 2. An earlier bearer. 3. An earlier ripener. 4. Larger fruit. 5. Richer in sugar. 6. Its great size gives it a distinct commercial value over others.

The new plums and prunes have been produced both by crossing and by selection of seedlings. Sometimes six or even more species are combined in crossing to get just the characteristic desired. In other cases, the new plum comes from uncrossed seed. Hundreds of thousands of the pits are planted and, out of the young trees which grow, the most

promising ones are chosen for grafting. These are grafted upon older trees, scores of them, perhaps, on a single tree, and all showing variations of leaf and fruit, presenting a curious and striking appearance as they develop upon the same parent tree. As the grafts develop fruit the choicest ones are saved for further testing in order that, out of hundreds of thousands originally planted as seed, only the very best may be eventually saved. Color and size of leaf, shape of branch, size, color and taste of fruit, general appearance as to hardiness and thrift, prolificness,—all these and other points Mr. Burbank has under consideration as he makes his selections from season to season in his search for the best of all. Selection here, as in the production of his flowers, is imperative,—always the best from the best.

The production of a new plum is not lightly to be entered upon, particularly when the scale of the work is that of Mr. Burbank's. First there must be a definite pattern, so to speak, in mind. If prevailing types of plums lack symmetry of form or beauty of color, the new plum must be planned to supply these

The development of the plum. The two larger ones are seedlings of the other two

deficiencies. If present plums are too small, larger ones must be made; if bearing scantily, more prolific ones; if injured by early frosts and adaptable only to certain regions, then a hardening of fruit and tree and an expansion of the zone of culture. Or it may be that the aim is to make a plum which assembles all these essentials in itself.

To accomplish all of this is not the work of a day nor a year, perhaps not of a decade. Very often the whole world will be searched for a plum which has one certain characteristic essential to the building of the plum under process. It may be, too, that when this foreign plum is found, apparently filling all the requirements, it may turn out no better than, perhaps not so good as, some plum of domestic growth. The mental pattern is made just as real and definite as the pattern of an inventor or the model of a sculptor. If the inventor, as his work advances, discovers some new feature which will make the invention more valuable, he will be quick to make use of it; and even the sculptor, in modeling his clay, may be in no small measure influenced by the living model before him. But even

more may the plant-breeder be influenced by change, for, as in any one of the new plums upon which Mr. Burbank is working, some new trait of surpassing excellence may develop wholly independent of his original plan. At the best, the metal or the wood of the inventor is only metal or wood, the clay of the sculptor is only clay; but the material upon which Mr. Burbank works is throbbing with life, as truly life, even if a lower order, as the life of the man who handles it—life that is sometimes wayward, sometimes stubborn, sometimes bursting forth in surpassing beauty or strength in lines never dreamed of, sometimes manifesting itself in ways spectacular, indeed even dramatic. All the time, while holding to his pattern, he must be on the lookout for important departures.

There are three vital points, in addition to many minor ones, which Mr. Burbank considers in the gathering of material upon which to build a new plum:

1. He must have at the base a hardy plum, wild or tame; for, without endurance, the product might be practically worthless.

2. He must have the best possible plum as

regards richness of food product; for, without this, his new plum would soon be detected by the public and cast out as an impostor.

3. He must have the most attractive-looking plum obtainable; for man delights to have beautiful fruit on his table; indeed, who shall say how large a part it plays with his digestion?

So, in general, these three basic points must be considered, in addition to many others, in making the ideal plum. In a somewhat contradictory sense Mr. Burbank has made a good many ideal plums, each one having some attribute in addition to the essentials and thereby causing it to be peculiarly distinctive.

For example, he has bred one plum with a delicious fragrance, so powerful that when left in a closed room over night the whole apartment will be delightfully saturated with the odor. Another plum has not only the essentials but it has a flavor wholly distinct from the plum, in fact it is not to be distinguished from the Bartlett pear. So marked is this characteristic that when one of the foremost fruiterers of the world tasted the plum blindfolded, not knowing what manner of fruit he

was eating, he pronounced it unquestionably the finest Bartlett pear he had ever tasted. Stranger still, as the plum developed, the tree has taken on much of the character of the Bartlett pear tree in leaf and structure, though why no one can tell, for it has never had the slightest pear tree blood in its veins.

Still another plum was developed which showed phenomenal bearing qualities, while also being otherwise excellent. It was so tremendously prolific, so to use the words, that its very fecundity stood in its way. Thus, wherever grown, hired "strippers," as they are called, must be engaged to go into the orchards when the fruit is green and strip the branches of all but just enough plums satisfactorily to mature. From a single tree by actual count 22,000 plums were stripped, enough even then being left on the tree to yield an abundant harvest.

Another plum which was made over to order, so to speak, has been almost similarly prolific. It was a small, dull-colored, bitter, wild plum, the American beach plum, unfit to eat unless cooked. It was a remarkable plum in many ways, growing on almost any

soil, frequently in places rejected by all other vegetation. It would grow on sandy soil or heavy clay soil, on desert-like places, and on soil which now and then is submerged by the sea. It would grow in the drought as well as in seasons of rain. In fruit it was remarkably prolific, though the fruit was worthless. The plums were not much larger than small cherries, usually less than half an inch in diameter, the pit being relatively large and surrounded by a thin layer of bitter meat. There were quite a good many varieties, some ripening early, some late, and all of them very hardy as regards frost.

It was this insignificant fruit that Mr. Burbank took under his care one day, seeing its possibilities and eager to ennoble it.

By the utmost care in selecting and breeding through a series of years, the homely little outcast has been made into a beautiful deep-purple plum, dotted with white, averaging at least three inches in circumference, without a trace of the old bitter taste in all its rich yellow meat. The new plum has all the staying qualities of the hardy little ancestor and will thrive in warm regions or frost belts,

on fertile soil or barren soil. The branches are so closely packed at bearing time that there is no room for leaves, only a solid compact mass of fruit.

But a more wonderful plum than any of these has been made by Mr. Burbank, a plum without pit. This plum has not been placed upon the market because not entirely finished, though the pit has been bred out of it. For about two centuries there had been growing in France a tiny plum, so called, with only a suggestion of a pit. Mr. Burbank took this plum, bred it with other plums to increase its size and beauty, and injected into it a rich new life. Years passed by in the testing, and at last the pit of the large luscious plum which was the result of the years of breeding has disappeared. It only remains now a matter of time to breed the pits from all plums and prunes and leave in their places so much more room for rich, nutritious food. More than one skeptical person, numbering among them some prominent scientists of Europe and America, has stood beside one of the many trees which bear these stoneless plums upon Mr. Burbank's proving grounds at Sebastopol

and has been asked to take his knife and cut one of the plums in two. The surprise then shown, sometimes deepening into an apparent distrust of their own senses, has been one of the most delightful and one of the most prized compliments Mr. Burbank has ever received.

There are two main lines in plum life as known in the fruit-growing regions of this country, one leading to the plum proper, the other to the prune. Mr. Burbank gives this definition, which has been adopted as practically covering the ground: "Any plum which will dry in the sun without spoiling is a prune."

The reason why the plums which thus become prunes take on this dried shape is because of their large sugar-content, which enables them, like raisins, to preserve themselves, as one might say, in their own sugar. The object of Mr. Burbank has been not only to make prunes which are larger in size than the old ones, but which are relatively richer in the amount of sweetness.

The prune has become one of the important items in the dietary of the nations, perhaps even more highly appreciated abroad. The

American prune has come more and more into favor in Europe. In fact, so desirable a prune is it that the French packers in season of scarcity at home import the California prunes, give them their own method of treatment, re-pack them, pay the American duty, and send them back in large quantities to the United States as prime French prunes. California prunes are also in marked demand for home consumption in Europe, largely supplanting the domestic product. This is shown by the steadily increasing export prune trade of the United States to Europe, and along with this goes a steadily decreasing import trade. In 1890–91 nearly thirty-five millions of pounds of prunes were imported into the United States, at a value of over two million dollars. Year by year since that time, with occasional fluctuations, the importation has declined, until, in 1904, the thirty-five millions of pounds shrank to less than five hundred thousand pounds, at a value of only $47,000. And out of the total amount imported a very large proportion was grown in the United States as noted, exported and re-imported.

From 1897 to 1904, inclusive, the export of American prunes was about two hundred and fourteen million pounds.

In 1894–5 the prune crop of California amounted to about sixty-five million pounds; in 1904 it had risen to one hundred and fifty million pounds, while, during the decade, one billion, one hundred and ninety-one millions of pounds were raised. Large quantities are also raised in the adjoining states of Oregon and Washington. In California alone there were, in 1904, nearly seven million, five hundred thousand prune trees in bearing.

While there are a number of varieties of prunes, the ones which Mr. Burbank has made are steadily advancing and supplanting the older varieties. It is quite safe to say that the influence of Mr. Burbank is becoming one of the greatest factors in the development of the prune industry of the United States, an industry which now has become a staple asset of the nation. Many thousands of people find employment in the picking and packing of this fruit as well as in the care of orchards, while vast sums of money are invested.

The production of plums has also been

greatly influenced by Mr. Burbank. Year by year he has given new plums to the markets, a long time elapsing, of course, before they make their way, because they must first be tested by him for a series of years in order to see that they maintain their standard, and several additional years must elapse before enough can be grown to supply commercial demands. But as each new plum comes forward, its excellencies at once appeal to the public, and the growers are hard pushed to supply the demand. While he constantly has in mind the production of plums beautiful to look upon, he pays particular attention to the shipping qualities. The plums must be not only beautiful but they must withstand long journeys by rail and water. So he has bred his plums with this in mind, and has made them firmer of flesh and skin—has given them endurance. Many illustrations might be given of the keeping qualities of the plums, but one will suffice. Some plums were sent from Santa Rosa by mail, of course without any of the aids of refrigerator cars. It was done as a test of their endurance. They were intended to be sent to a point in Virginia, but, by mis-

take, went to Vermont and, there being no delivery, they were returned. After having made the trans-continental journey twice by mail, they were as fresh and fine of appearance and as luscious to the taste as the ones picked from the trees upon the day of their arrival in Santa Rosa, after their long journey.

As rapidly as he has perfected a plum or a prune, it passes from his hands and others reap the profits,—but he has accomplished his object, he has given something new and helpful to the world. While he has the fine true imagination of the poet and a nature in closest harmony with all that is beautiful, at the same time he sees things from an intensely practical point of view. Upon this practical side of his work he has some decided views. He says:

"With the world as a market, competition is keen, and only the best fruits in the best condition will pay; fortunately, it generally costs much less per ton to produce large, first-class fruit than to produce the poorest and meanest specimens that are ever offered. Small fruit exhausts the tree much more rapidly than large fruit, as one pound of skin, stones and seeds represents at least ten or

twelve pounds of fruit pulp; it will thus readily be seen that improved varieties which produce uniformly large, fine fruit are more economical manufacturers of fruit, and also that the product is more salable; the difference in many cases will decide between success and failure.

"Many varieties have two or three superior qualities, but woefully lack in many others. Some have a very weak and imperfect root system, no matter on what stock they may be grafted; others have scanty foliage, which readily falls a prey to drought or to fungus or insect enemies. Others are especially subject to blossom blight by late spring frosts, parching winds or rains. Still others, though bearing the best of fruit, are so sparing of it that they are outstripped by others of less value. Numerous other faults are too well known to all observing fruit-growers.

"The fruit-grower of today is strictly a manufacturer and should have the latest and best improvements. The manufacturer of pins and nails would not long tolerate a machine which failed to produce pins and nails every other season, or one which produced even

The giant plum, not only of largest size but of great richness and prolific in bearing

occasionally an ill-assorted, rusty, unmarketable product. And, revolutionary as it may at first thought appear, there is no good reason for permanently producing poor fruit; for in time new trees will be produced which will produce good fruit with the utmost regularity and precision. Of course, there never can be one variety which will be the best for all purposes, but it is perfectly possible to produce varieties which, for their own special use, can be relied upon to yield full crops of the best fruits without fail; all this must be done by careful selection and breeding.

"It has been said that it were better for a man that a millstone be hung around his neck and that he be cast into the sea than that he should introduce a fruit or flower which should prove to be of no value. In the introduction of a fruit or flower, no one who has not been through the experience can fully appreciate the sense of responsibility, and no one can more deeply lament a failure than the introducer."

It will be of interest to note here some of the more prominent among the plums and prunes which Mr. Burbank has produced:

1885—"Burbank" plum, "Satsuma" plum, imported from Japan with numerous others; improved, and introduced.

1893—First Japanese-American hybrid plum "Gold"; introduced.

1893—"Splendor" prune; introduced.

1893—"Wickson" plum; introduced.

1893—"Delaware" hybrid plum, "Juicy" plum, "October Purple" plum; introduced.

1893—"Hale" plum; introduced.

1894—"Giant" prune; introduced.

1894—"Doris" plum; introduced.

1898—"America," "Chalco" and "Apple" plums; introduced.

1899—"Climax," "Sultan," "Bartlett" and "Shiro" plums; introduced,

1899—"Sugar" prune; introduced.

1901—"First" and "Combination" plums; introduced.

1901—Many stoneless prunes; originated.

This does not by any means include all the plums and prunes Mr. Burbank has produced which have shown desirable qualities, but only such ones as have shown unusual fitness to live. Hundreds of thousands of others are now under test. It would be idle to attempt a

prophecy of the value of such of these new plums and prunes as are finally chosen. They are not only likely to supplant all those plums hitherto produced by Mr. Burbank, as well as those in existence when he began his work, but, through the elimination of the pit and the substitution in its place of that much more nutriment, relentlessly drive out of the market all the standard prunes which now furnish the world's supply.

CHAPTER VIII

THE SHASTA DAISY

THE green hills rising behind the house where Luther Burbank was born were ever an inviting place in his boyhood days. He knew the haunts of the wild flowers and the hour of their earliest appearing. From the time the snows gave way to the spring sun until they came again in the bleak November days, he was in constant intercourse with the hills, learning the language of Nature in the only school where it is taught without an interpreter. Something in his own nature brought him into instant contact and sympathy with the great heart of the Nature around him. A certain peculiar intimacy with Nature grew up and produced, if one may so put it, the most absolute frankness toward her and trust in her. This was well illustrated one day in his maturer years when a great scientist called upon Mr. Burbank, Dr. Hugo de Vries, of Amsterdam, certainly one of the leading

botanists of his generation. The two men were in deep consideration of some of the most profound processes of Nature, when de Vries made some remark in which there was a suggestion of the unreliability of Nature.

"You are wrong! Dr. de Vries," Burbank instantly replied with great earnestness, ignoring for the moment all scientific topics in order to come to the defense of his vast friend; "you are all wrong; Nature never lies. We may sometimes misunderstand her, we may not always be able to speak her language or properly translate her thoughts, but Nature never lies."

The great botanist sat some time in silence, and then gravely nodded his head.

There were many flowers upon the green hills around his boyhood home that the lad loved, violets and asters; the royal goldenrod; that soft breath of the spring, the delicate anemone; roses and lilies and the trailing arbutus in their seasons; but there was one flower in which he took a particular interest, possibly because every man's hand was against it. This was the little wild field daisy, to many a farmer an unmitigated evil, a pest to be fought

at every possible point, a vicious, persistent weed. When he had begun his market gardening and seed-raising, he frequently went to the hills for wild flower seeds, planting them in his garden and observing with curious interest how the plants sometimes varied from the parent plants. A certain chivalry, it may have been, a desire to reclaim the daisy from the company of the outcast weeds, caused him to include it also in his experiments. He found the daisy no less striking in its variations than the other plants.

There came a day in after years when he was to demonstrate again his interest in this little waif, to become its champion in a still larger way. For he had laid out in his mind a scheme for the ennoblement of this flower;—he would lift it from its low estate among the serfs and make it a queen.

In England there grew a daisy larger than his little wild friend and coarser in stem and flower. In Japan grew another daisy, not large, but of exquisite purity of color and almost dazzling whiteness. On the Massachusetts hills grew the American daisy, small, tenacious of life, hardy of constitution, not so

One of many rows of seedling Shasta daisies from which selection is being made. The rows are seven hundred feet long

white in its petals as its distant Japanese relative, not so large as its English cousin—he would unite the three. In order that the very best results might follow, he searched through a number of states, as time and opportunity offered, getting the best native wild daisies from New York, Pennsylvania, New Jersey and Massachusetts, and from these best ones chose the best of them all. Sometimes, as happened in several instances with the daisy, he will be making a short journey by rail and, looking out the window, may see, as the train flashes by, some particularly striking patch of flowers. At the next station he gets out and either buys a ticket back to a station nearer the flowers or walks back to them, and then selects from them the choicest plants for use in some experiment under way.

So from three continents he chose a daisy, the best he could get;—from them he made a fourth, the most wonderful daisy ever seen.

In setting out thus to make a new flower out of old ones, Mr. Burbank does not depend upon any rules laid down for him by some one else. While he is never destructive but always constructive, aiming to create new forms of

life that shall be better than the old, he is restive under rules. If such were imposed upon him, it would be but natural that he should at once proceed to break them, not so much for the delight of breaking them as a protest against conventionality. He does not start out among his flowers in the dawn of a spring morning with a book on botany in one hand and a treatise on plant-breeding in the other. Had he done so, there would have been no Luther Burbank. He utterly ignores much of what so-called scientists have set down. Nor does he depend upon scientific nomenclature unless it is sensible. In his conversations he is peculiarly free from scientific terminology; so direct and simple is his speech that the greatest scientist and an unlettered farm laborer may sit side by side and both understand. I cannot better illustrate this than by a single word which I saw on a box high up in his storehouse of rare seeds and bulbs. The box contained seeds that for some reason had been carefully sterilized. The outside bore this word, written in bold letters: "Boiled."

This word bore a volume.

In the scheme laid out for the new daisy there were certain well-defined characteristics to be developed; a fact that illustrates how systematic and precise his work. He wished a daisy that should have grace, beauty, hardiness. He wanted a slender but firm stem at least two feet in length, free from all branches; a blossom larger than any daisy ever before seen; petals of the purest white. And so seeds from these plants from distant quarters of the globe were sown, and when they came to blossom he crossed them, combining each with the other, joining them in a union as intimate as life, as powerful as death. For he was compelled to put to death their old selves; —their life-long habits, their manner of life,—even their form and texture, all must give way;—and from this death he would bring forth a resurrection.

So completely was the pollinating done that after the merging was ended the strain of blood, so to call it, of each plant now flowed in the veins of one. And yet this act of fertilization or hybridization or new birth, call it what you will, was but an incident in the creation—the great struggle was ahead.

The seeds from the first united flower were not more than six or eight in number. These were sown, and from the plants which grew only the very best and those approaching the ideal were chosen, so that at the second stage of the test there were probably fifty seeds. This, of course, gave a greatly enlarged number in the progression, and soon there were a hundred thousand seeds, all having come from plants which had been selected from their fellows. These hundred thousand seeds were sown in a box of earth about ten feet square, at the home grounds at Santa Rosa. Great precautions have to be taken to prevent the birds and other pests, as gophers, moles, and worms from doing damage, as well as to provide against various plant diseases. One gopher or one flock of thievish birds may undo in an hour the work of years.

As soon as the plants were large enough to transplant, they were taken up and set out again at Sebastopol on a plot of ground an acre or more in extent. The ground had been the scene of many another wonderful experiment; for the earth at Sebastopol is no sooner relieved of one absorbingly interesting test

than another is ready—there has never been another plot of earth with such strange experiences in the history of the world.

In this act of transplanting, and indeed, in every other act in these experimentations, the utmost care is necessary. There is much work which Mr. Burbank cannot delegate. Certain things he can assign to others, but he will not delegate any work to hands not in sympathy and closest touch with Nature. The men to care for this new field of daisies must be those who not only know how deftly to remove weeds, how to note and guard against all the ills a plant falls heir to, but they must be men of keen and intimate sympathy with the work itself. The men who do this work are picked men, picked among thousands. So very many applications for work under Mr. Burbank are made that he early gave up answering by personal letter, and printed forms are sent out, kindly but clear. Many graduates of universities and colleges are among the number. The very gentleness and modesty of the man frequently have been misunderstood by these young men fresh from their books; and, literally running over with information, they have

hastened with all sincerity to give him the benefit of their knowledge and to furnish him with pointers for the carrying on of his work. But while he would never discharge a man because he was a university graduate,—for he has an ardent sympathy for all higher education that is sane, symmetrical, and devoid of veneer,—yet he has never been able to keep in service a single university student. Time and again some enthusiastic young fellow would enter upon the work, and, bred to the nomenclature and the traditions of the scientists, would at once begin enlightening Mr. Burbank on the best plan to follow in a given instance, forgetting that the silent man patiently listening to him stood at the head of the plant-breeders of the world.

Not only does he demand sympathy upon the part of his workmen and the rarest intelligence obtainable, but he demands absolute sobriety. Much of the work of pollenation, grafting, budding, seed-sowing, and even so apparently simple a piece of work as the removing of weeds from around thousands of the tiny plants, requires the very steadiest of nerves, so that no workman may use tobacco

or liquor in any form, or any manner of stimulant that will befog a brain or benumb a nerve.

When the hundred thousand daisies were well started in their new home, selection began,—as important an act in its way as the act of breeding by which they were brought into being. During the six months that they were in bloom, they were subjected to constant supervision and scrutiny. Twice a week the entire field was scanned by an eye that has perhaps never been equaled for perceptiveness. The variations from the parent stock in leaf, stalk, petal, size—all were noted, and the instant a plant was found which in any one of these particulars threw light upon the general problem, it was set apart. Now and then there would be one with grace and strength but no beauty, again one with a wonderful blossom on a stumpy little stem, now one on a lovely long stem but cloudy as to color.

In all such work Mr. Burbank carries with him a small ivory rule, with which he takes constant measurements of stalk and blossom. The length and width of the petals, as

well as the span of the whole flower, are important. The object of these measurements is to find the plants which are coming nearest to the ideal in his mind.

Out of the hundred thousand plants, those were chosen which came nearest this ideal and their seeds were in turn planted. This process was repeated for eight years. In the process of development that which often happens in his tests was seen,—certain plants produced what might be called unnaturally large and beautiful flowers. Sometimes the bloom of a single daisy would measure very nearly two feet in circumference, seven inches from tip to tip of petals. At first thought, these plants would be the ones naturally to be chosen from all the others. But not so. They had grown to their great size under peculiarly favorable conditions, both of climate, soil and supervision. The aim in creating these plants was to fit them for the general public, for the flower lovers of the world; for Alaska and Florida, for Norway and Italy; for all sorts of soil, climates and people. It would be rare, indeed, that they would receive more than the average treatment of the average gardener;

One of the "Shasta" daisies. The blossoms are from four to six inches in diameter

never would they find another such a master as they had had.

So average conditions must be taken into account, and an average best flower be made for these conditions. It is a cardinal principle of Mr. Burbank's life never to let a plant deceive him by show of some surpassing excellence which, under ordinary conditions, would not be apt to manifest itself. "If I deceive myself," he puts it, "I deceive the public, too." From the medium plants the stock was grown and re-grown until he produced a flower at last combining all the desirable qualities with adaptability to average conditions. This flower was from three inches in diameter for the smaller ones to over six inches in diameter where conditions approached the ideal.

In breeding these new daisies still another attribute was constantly in mind, that of hardiness, hardiness in the growing plant, keeping qualities in the cut-flowers. So all through the tests only the sturdiest plants were kept; all the weak and sickly ones were at once destroyed. It was for this very characteristic of endurance that the little wild daisy,

with its tenacity of life and its ability to withstand heat and cold, was chosen. So when the end came a flower was produced that would grow equally well inside the arctic circle and under the equator. The cut-flowers, too, will remain fresh and beautiful in water for from three to six weeks. A gift of some of his choicest stock which graced a Thanksgiving table was still beautiful at Christmas.

As Mr. Burbank puts it, they will grow anywhere out-of-doors where it is not cold enough to kill an oak tree, and they will grow for anybody. They are perennial, increasing in number of blossoms from year to year. But if, at the first, the plant is left to itself it will blossom itself to death the first year. All but one or two of the first buds must be removed, and sometimes not a single one is left. Thus treated, the plants strengthen themselves and, after the first season, a single clump will bear from two hundred to five hundred of the huge white blossoms. The plants may be multiplied indefinitely thereafter simply by dividing them at the roots. They will blossom for several months in the average temperate zone climate, in California blooming six months or

more out of the twelve; under specially favorable conditions, throughout the whole year.

An extremely interesting feature of the new flower is that it seems to have lost all its bad habits. Where once it was, at the best, a pest to be dreaded, multiplying with remarkable rapidity and driving absolutely necessary food products to the wall, it now keeps itself apart from the weeds of its ancestry in a certain aristocratic exclusiveness. It produces but very little seed and that large in size. Mr. Burbank has grown millions of the plants in his tests, but a self-sown daisy has never appeared upon his grounds.

The flower itself is one of remarkable beauty, a rare, well-nigh brilliant white of great size, the center a pure yellow, with long, graceful stems. It is not only highly decorative in the mass, forming a magnificent note in garden or lawn, but it lends itself with a grace all its own to the bride at the altar or for the last tender tribute to the dead. From the first time he saw it, Mr. Burbank had always held in deep veneration Mount Shasta, a snow-capped peak of the high Sierras, one of the conspicuous landmarks of California.

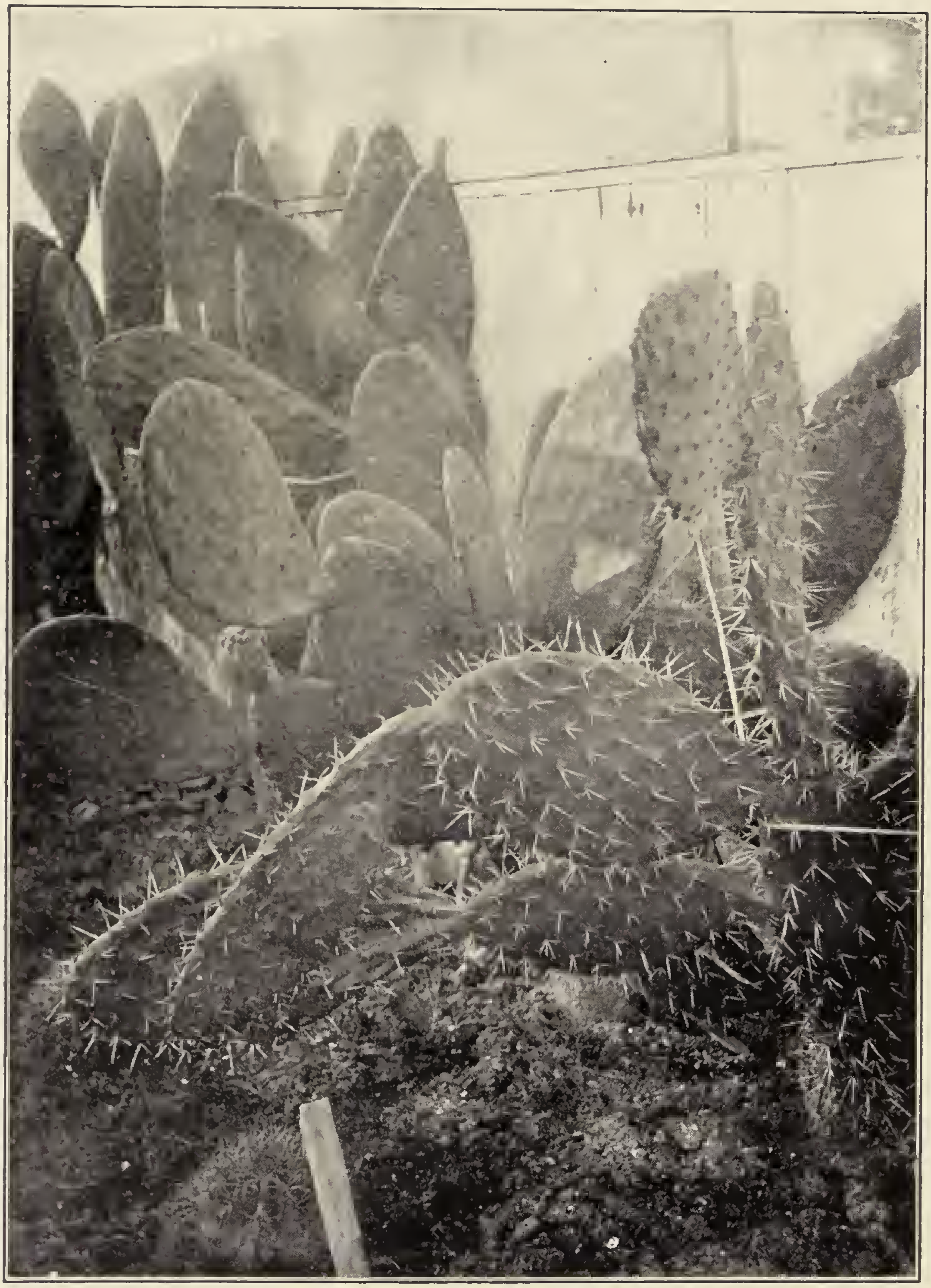
As the name of the mountain means white, and as its summit is always covered with a coronal of snow, he chose the name as peculiarly fitting for such a flower.

Now and again Mr. Burbank creates some flower or plant which to him seems practically perfect; that is to say, it is so nearly up to his ideal that he does not think it necessary or profitable to give any further time to it. Again, he leaves a flower in its class by itself, perfected as far as his hands may make it, and then fashions another from the material that was left over. The new flower may have certain characteristics of the completed one, but it will have others so very different it becomes a practically individual creation. In the breeding of the daisy some peculiarly interesting and curious variations are developed. In certain plants these variations assume what are called abnormalities, while in other cases they are irregularities,—irregular but undeniably beautiful. Certain of the hybrid daisies showed a tendency to become double, their petals in some cases also being strangely convoluted. The doubling was somewhat in the manner of the chrysanthemum. This tendency was en-

couraged, and gradually, led onward from year to year, the petals multiplied in number, crowded closer and closer into the golden center, until, finally, a completely perfect double blossom was produced, even larger than the Shasta, entirely white. In form it suggests the chrysanthemum, though quite distinct from its Japanese friend in character and promising to become a notable rival. It differs also in length of blooming time, its period extending over five to six months instead of the one month of the chrysanthemum.

Hundreds of flowers have passed through some such life history as this at the hands of Mr. Burbank. Some have been led in one direction, some in another, but all led upward to a more beautiful life, all glorified by his touch. Many years of his life have been crowded to the utmost with the details of what may be called utilitarian productions, forms of plant life whose chief value is to add to the wealth of nations. It would be quite impossible to say how many millions of dollars he has thus added, nor would it be in the reach of the imagination to estimate what the world is yet to reap from his sowing.

And yet, in the midst of his labor for the practical good of the race, he has never lost sight of that more exalted resolve to leave the world a far more beautiful place than it was when he entered it.



The cactus in the foreground is the ordinary thorny kind. Those in the rear are the thornless ones of the same species

CHAPTER IX

THE THORNLESS EDIBLE CACTUS

THE problems which confront Mr. Burbank in his work are many and sometimes of great difficulty. One plant may present a simple nature and a comparatively short life history. Another may be exceedingly complex in nature and of great age. The first he finds easy of manipulation, the second often very difficult. The plants with millions of years back of them, which may be traced in the very rocks themselves, are likely to prove stubborn, to persist in their old habits; or, if they at first appear to yield, to return to these old habits at a later day.

He has found this particularly true of the cactus, in the changing of which he has accomplished one of his most wonderful achievements. For years he had had the cactus under consideration. It had long seemed to him that it should be taken out of its environment and set forward among the

helps instead of the hindrances of the race. Sometimes he comes instantly to a conclusion, seeing immediately the bearing of things and setting out upon a certain course fortified at all points. Sometimes, as in the regeneration of the cactus, he is met with grave problems which demand profound study.

When he turned to the cactus on which he was to spend more than ten years of study, it was, in the main, a stubborn, irreconcilable foe to the race; in order to make it a friend of man its whole nature must be changed; it must be re-created. To the average man it would seem a waste of time and energy to seek to improve a plant which for millions of years had been hostile to the race, which seemed to have absolutely nothing in common with civilization, which by its pariah-like nature seemed peculiarly fitted for a home upon the desert, its closest comrades the rattlesnake and the scorpion, its highest aim, apparently, to cause the death of some thirst-maddened animal driven to eat its juicy but deadly leaves.

But, the more difficult the problem, the keener his desire to solve it. He knew that

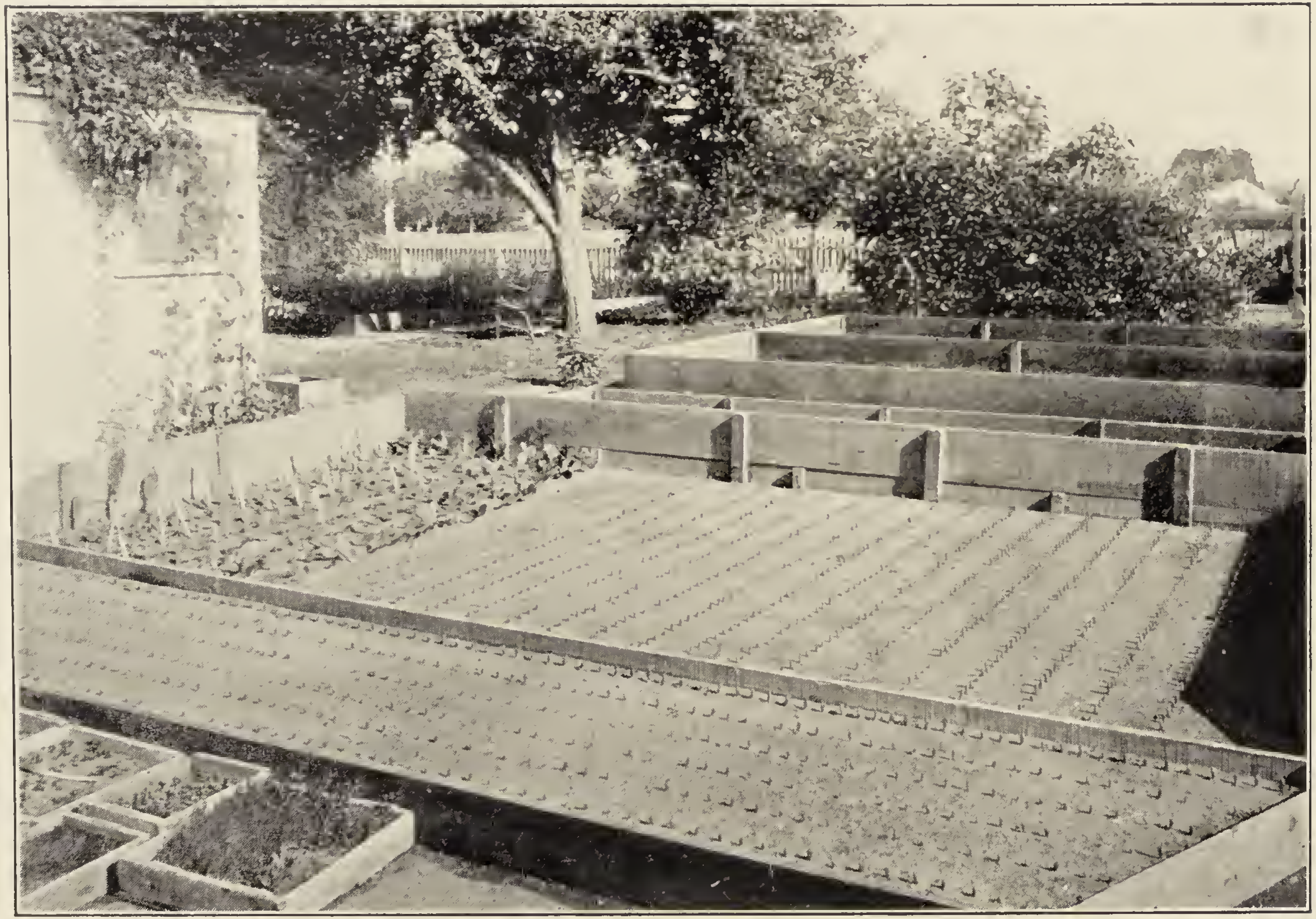
the cactus, even in its wild and defiant shape, had certain unquestioned excellencies. It was undeniably hardy; it would grow and thrive where nothing else would, welcoming the blistering heat of the desert and growing powerful where rain seldom falls. It had much that was nutritious, both in its thick thalli, or leaves, and in its golden or crimson fruit. Wherever it had been given a chance away from its desert home and under more favorable conditions, it had shown phenomenal thrift. It was not one of those plants which will not bear transplanting from a wild to a civilized state.

Two main obstacles had first to be removed —the countless thorns upon the cactus, covering branch and leaves and fruit, and the spicules of the leaves, the woody fibrous skeletons of the thalli which made them more or less indigestible. These overcome, there remained the development of the fruit and the fitting of the leaves to be a food, food even for man as well as beast.

All this he has accomplished,— nothing more marvelous has ever been done in plant life. It would be exceedingly difficult to say

which one of Mr. Burbank's creations is the most valuable to the world from a practical point of view, which one adds most to the wealth of nations. But probably no other creation has surpassed this one, for it provides for the sustenance of the race, food for man and food for beast; it utilizes the vast desert areas of the world without the intervention of irrigation, though irrigation will aid here as elsewhere; it converts enormous reaches of semi-arable land in all zones to profitable husbandry.

It had long been known that there were certain kinds of cactus growths having few, if any, thorns and certain ones the fruit of which natives of some countries considered edible. It sometimes happens in Mr. Burbank's work that the essential thing is to combine excellent attributes and eliminate bad ones, rather than to create a wholly new plant. And so it was in the case of the cactus. And yet, in one sense, the cactus he has produced is absolutely new, because no other cactus has ever combined so many excellencies, devoid of obnoxious elements,—he has bred out the bad and bred in the good. It is quite like the



Cactus tests.—Thornless, hybrid seedling Opuntias, now eight weeks old from seed. They will be transplanted later, after rigid selection

touch of a great poet who finds the prosy story of a Hamlet or a Lear and leaves it a masterpiece.

Out of some twenty genera of cacti, recognized by naturalists, only five occur in the United States, but these are among the most varied of all in their species, so that the one thousand known varieties of cactus are nearly all restricted to America. It is upon one of these five, common to the United States, the Opuntia, that Mr. Burbank has worked as a basis. It is of the variety having flat, thick leaves, though sometimes inclined to become cylindrical. It is a native of Mexico and South America. In their natural state their flowers are very striking, some of them red, others purple, others yellow. One of the species of the Opuntia is cultivated in Mexico as a host for the cochineal insect. The insect thrives upon its leaves, is killed at the proper time and dried, and from it is produced the brilliant carmine color so useful in commerce. The juice of the fruit is sometimes used as a water-color for painting and for coloring confectionery. Along the shores of the Mediterranean are several species of the Opuntia, the

fruit of one of which is called the Indian fig and is much liked.

One of the Opuntias is hardy even in Alaska and in other similar climates, a characteristic which has had an important bearing on the work. This cactus was called in, also, for the scheme laid out contemplated not only a cactus without thorns and spicules and preëminently a food, but one which should be adapted to the arctics as well as the tropics, one, as Mr. Burbank puts it, which will grow anywhere where man can live from the soil. Other varieties were also chosen, one for one characteristic, one for another, but all essential in the building up of the ideal plant.

Seeds were secured from all the different varieties needed and planted by the thousands in beds specially prepared. The plants were in rows a few inches apart, from two to ten thousand plants to a bed. Extensive crossings were made by pollination as soon as the blossoms came, this being followed up for several seasons. The object of this crossing, or hybridization, was to break up radically, once and forever, the habits fastened upon the plants for perhaps millions of years. Seeds from

these new plants were then planted. So persistent is the cactus in its habits that thousands of new seedlings showed no tendency toward improvement. Indeed, many of them, as if in very defiance of man, bore uglier thorns than any of their ancestors. Many of them were a mass of woody fiber. But some very few showed that a profound change was coming over their lives. This was indicated by a notable lessening of the spines, thorns and bristles. All such plants were isolated for further crossing and selection. Tests were going on all the while, also, to ascertain whether or not any plants were losing their spicules. Such as were found improving in this direction were also isolated. And so for every excellence desired there was the sharpest scrutiny, and also for every bad feature—it was a daily battle for the best. At last, when ten years had gone by, the end of all this preliminary breeding and crossing and selecting came, and alongside the white picket fence which surrounds the home of Mr. Burbank rose a giant cactus, fully eight feet in height, bearing thalli or leaves from ten inches to a foot in length, five to eight inches in width,

nearly an inch in thickness, bearing fruit of large size, not a thorn upon it, not a spicule in all its rich meat,—the bitter enemy of the desert converted into an abiding friend of man.

In creating this edible, thornless cactus Mr. Burbank took into account a thousand and one things which may find no mention here, but one of them which may be noted shows how persistently practical is all his work. It takes much of the vital forces of the cactus to make its powerfully constructed thorns and to supply its thalli with spicules. In breeding these away from it he gives to Nature the opportunity to devote all her energies to the production of food and fruit, and this will have a most important bearing upon the future; he has not only transformed the cactus as to its product but has, in removing these thorns and spicules, provided a means for vastly increasing this product.

The fruit of the new cactus is in shape quite like a fat cucumber slightly flattened at both ends. It is about two and one-quarter inches in diameter by three and a half inches long. Sometimes it is a beautiful yellow in color,

What the thornless cactus will displace—A hint of desert conditions

while in the fruit from another plant the flesh is crimson. It is delicious to the taste. To some it has the flavor of a peach, to some a melon, to some the suggestion of a pineapple, to some a blackberry—to every one who tastes it a different flavor from anything before eaten. It is, indeed, a new taste for the palate of the world. It may be eaten fresh or cooked, or it may be preserved. The thalli, too, have a peculiarly attractive flavor when cooked and may be eaten in a variety of ways, or they may be put up as ginger or melon rinds are preserved. As a food for cattle the thalli are peculiarly rich, at least one half as nutritious as alfalfa, and they will produce the finest beef, mutton and pork.

It is quite significant, it may be said in passing, that at a time when industrious explorers of the United States Government were scouring the desert places of the earth in search of a thornless cactus which they thought might be introduced into the arid regions of America, finding at last in Algeria a prickly pear almost spineless, Mr. Burbank had been for years cultivating tens of thousands of cacti upon his proving grounds,

thousands of them at that very time practically thornless and spiculess, and all marching forward under his direction to produce a cactus which should not only have none of these undesirable things but which should have many others of distinct value to man.

An indication of the wonderful growing powers of the new cactus is seen in the fact that in three years' time a single plant from seed produces six hundred pounds of food.

Another, and most important, feature of the new cactus is that it has begun to breed true to type, from the seed, while it, however, invariably persists from cuttings of the leaves. The cactus, as well as all other plants, stubborn or pliable, persists when once it has been definitely fixed in its new ways. Just as the cactus through all the ages has persisted in bearing thorns and persisted in filling its thalli with spicules, just so it will persist in getting along without them when once it has been fully broken of the habit of bearing them. So the new cactus begins a new era in its family, an era of unexampled prosperity, and the era of good will and not enmity to man.

The possibilities of the new cactus have an

enormous scope. The desert land on the globe is estimated to be two billion, seven hundred millions of acres, an area six thousand square miles larger than the area of the United States inclusive of its insular possessions. All this save, perhaps, in some case where absolutely no rain falls, may be reclaimed for food for man and beast if needs be. The regions known as steppes, much of which is semi-arable, is estimated at nearly nine billions of square miles additional, practically all of which may be utilized for the new cactus. The fertile regions of the globe are considerably larger than both these regions, some twenty-nine millions of square miles, over sixteen billions of acres. On every foot of fertile soil the cactus will grow with still greater rapidity than in the desert, for it takes on a new and powerful impulse under cultivation.

These figures give something of the possibilities. In Mr. Burbank's own words:

"The population of the globe may be doubled and yet, in the immediate food of the cactus plant itself and in the food animals which may be raised upon it, there would still be enough for all."

The new cactus will not be raised to sell. It is not at this time fully ready, for while the main end has been reached, other work in it must be done before it begins its career. As soon as it is finished, any man with a few feet of earth in the corner of some city back yard, any man with a garden in the country, any man with acres which have lost their fertility or with large areas on mountain or desert which have been long abandoned, may become a sharer in the fruits of this act. For here, as in all that he has ever done, the supreme purpose of his life looms up, colossal in its contrast with the mean selfishness of man: He has done all for the advancement of the race.

This fearsome dreaded foe of the race has been conquered, the times of little rain are set at naught, the great flame-hearted sun itself, burning its mighty way across the blistering desert is defied, the whole desert and arable regions of the globe by the act of one man may become a limitless reservoir of food.

One of Mr. Burbank's rare roses

CHAPTER X

CERTAIN GENERAL FEATURES

IN a study of Mr. Burbank's great work one is not less amazed at its extent than baffled by its variety. His approach to Nature lies through many avenues;—it is a source of never-ending surprise to see how completely he commands these avenues while steadily opening others.

In this chapter it is proposed to touch upon some of the many experiments which may not be incorporated in this volume as individual chapters because of the limitations of space, though in them may be found ample material for such chapters.

Roses have long held high favor with Mr. Burbank, both because of his love for the flower itself and because of its possibilities in the way of increase in size, enrichment of color and odor, and in the adaptation of certain roses, highly prized but confined to a restricted zone of cultivation, so that they

may be elsewhere enjoyed. Some years ago he developed a rose primarily for bedding purposes, purchased by an eastern florist and by him put upon the market, the Burbank rose. It seemed to catch something of the tremendous energy and enthusiasm of its creator, for it soon made itself felt as the freest flowering rose in cultivation. It begins to blossom when it is not more than three inches in height and, if the climate will permit, it keeps on blossoming the entire year. In colder climates it goes into winter quarters unafraid, and hastens out of its long sleep at the very earliest call of spring. It is a double rose, a deep rose-pink in color, beautifully shaded from the center and nearly three inches in diameter. In colder climates, when October days come the outer petals take on a carmine hue. The plants develop into symmetrical bushes, adding to their attractiveness.

This rose ran the gauntlet of the World's Fair in St. Louis, in 1904, and won the gold medal over all competitors as the best bedding rose in the world. It is only one of many superb varieties of roses which Mr. Burbank has made.

The pineapple quince, a greatly improved variety having the flavor of the pineapple

Mr. Burbank was attraeted by a wild everlasting flower which produces a rather inferior blossom in its Australian home, but whieh promised to develop into something far more attractive. Following the usual eourse of seleetion, he chose from among its plants those bearing the choicest blossoms, saved the seeds from these plants, and thus by constantly ehoosing those plants that approached the model in his mind, carried the flower forward through sueeessive generations to a larger and far more beautiful state. The eolor of the blossoms, a delieate pink, was intensified and the blossom itself doubled in size.

There are numerous "everlasting" flowers, more or less attractive to the eye, and to add a new flower to their list would not have been so extraordinary a thing, but the development of the Australian flower had a wholly distinetive purpose, the produetion of a flower for use in the manufacture of millinery goods and for use in allied deeorative lines. Thus the new flower becomes eommercially important, promising very largely to displace artifieial flowers of wire, paint and eloth for the adornment of women's hats. The flower is not only

beautiful in form and color and everlasting, but it is fadeless and will not be injured by handling. One of the largest millinery manufacturing firms has contracted to buy the flower. Mr. Burbank makes note of the fact that there are other flowers of this kind susceptible of like improvement.

Fifteen years ago Mr. Burbank, taking into account the fact that the quince can be grown with probably less expense than any other fruit and that it had never occupied the place which he thought it should occupy, set about its improvement. It is said that some of the choicest so-called quince jellies on the market have been made from the refuse of apples, pears and other fruits brought up to the imitation of the quince flavor by judicious doctoring. The quince itself had long been neglected by fruit-raisers, and, at its best, was an inferior fruit compared with other fruits.

The "pineapple" quince was the outcome of all the years of work upon this fruit, a quince which, as Mr. Burbank says, "will cook as tender in five minutes as the best of cooking apples and with a quince flavor not before equaled. Jelly made from it is pronounced

by some superior to that made from any other fruit. The fruit in form and size very much resembles the Orange quince but is smoother and more globular; in color much lighter yellow, with an average weight of about three-quarters of a pound each." Still other varieties are under way which promise to far surpass even the pineapple quince.

For many years Mr. Burbank has carried on extensive tests in berries of different kinds. Many tests are still under way at Sebastopol. One of the most important features of this line of work is the ultimate removal of the thorns from all thorn-bearing berries, and from roses as well. Mr. Burbank asked me one day, as we were walking through the proving grounds at Sebastopol, to bend over a blackberry bush growing rather close to the ground, and rub its stem against my face. It certainly was a novel experience—the thorns had been entirely bred away from the plant. So will it be with all thorn-bearing fruits if he shall find time to transform them, for, as in this particular instance, all that is essential is that a systematic and patient course of selection be followed.

One of the rarest of all the fruits which have come from Mr. Burbank's hand is the white blackberry, the union of a small light-colored wild berry, of no particular importance, and a Lawton blackberry. The union gave to the new plant great vigor and large size to the berry, the berry, at the same time, losing the dark purplish black of its larger ancestor and appearing a clear, beautiful white. The fruit is not only fair to look upon, but delightful to the taste. Some idea of the vastness of the work even in the production of berries is shown in the fact that in producing the white blackberry sixty-five thousand hybrid bushes which did not come up to the standard set for them were destroyed at one time. One plant out of sixty-five thousand, but the one successful plant paid for all the time, the trouble, and the infinite patience which had been expended. He is still working upon the white blackberry in order to give it still finer flavor and to increase its productiveness.

In the crossing of the various berries, notably the blackberry and the raspberry, remarkable variations in both stalk and leaf

were seen. The stalks varied greatly in color, also, some of them white, some red, some dark purple, some bronze, some yellow, some of them brown or green or black. The leaves were remarkably interesting in their wonderful diversity. Literally scores of leaves, all different in shape and size, grew from the seed of one hybrid blackberry plant.

A few seeds were secured for Mr. Burbank by one of his collectors from a blackberry growing in the Himalaya Mountains. The plants which came from the seeds were selected through a series of years with the end in view of encouraging and still further developing the rapidity of growth which was said to characterize the foreign berry. At last a single plant, a young plant at that, was developed which covered one hundred and fifty square feet of ground, stood eight feet in height, and bore over a bushel of fruit.

I saw growing on Mr. Burbank's grounds at Santa Rosa a row of plants apparently but lately out of the ground, possibly an inch in height. The row was about six feet

long, a clearly defined green line on the dark earth. A foot or so from the tiny plants was another row double in size. Alongside of this were other rows, larger and thriftier of growth than the preceding one. At the end of the plat which embraced the test, was a heavy row of rich dark grass, broad of leaf, dense of growth, the leaves being from ten to twelve inches long. The plants had a remarkably brilliant green color and were the picture of vegetable health. The experiment was in grasses, a line of work Mr. Burbank has begun with the promise of important results. Indeed, he once carried on a series of grass tests, developing a number of rare grasses remarkable both for rapidity of growth and variety of color, but was obliged to discontinue the tests at the time. In these tests the possibility of development in grasses was clearly proven.

In the experiment noted above, the tiny inch-high grass was of the same variety as the largest plant in the test. While it had been growing its inch the other had been growing twelve inches, the surface of the one plant being fully five hundred times as

great as that of the companion of the same lot of seed. The difference between the two was that one was a slow-growing, the other a rapid-growing seedling. As in all manner of fruit tree and other tree tests the seedlings vary greatly in the rapidity of their growth, so in the grasses,—the test under way was to determine which one of these seedlings was the fastest growing and most vigorous; from that final selection would be made in the development of a better type of grass. Mr. Burbank has been studying for a long time the question of providing a rich, nutritious grass for barren regions. It is on this line he has been at work, as well as upon the production of lawn grasses which will grow much more compact and get along with less water than the old types of grass. The tests in grasses promise to be of exceptional interest and value.

Mr. Burbank also recognizes a large field of operations in the improvement of native wild grasses, and even in the ennoblement of the weeds themselves. Upon this point he says:

"What occupation can be more delightful

than adopting the most promising individual from among a race of vile, neglected orphan weeds with settled, hoodlum tendencies, down-trodden and despised by all, and gradually lifting it by breeding and education to a higher sphere; to see it gradually change its sprawling habits, its coarse, ill-smelling foliage, its insignificant blossoms of dull color, to an upright plant with handsome, glossy, fragrant leaves, blossoms of every hue, and with a fragrance as pure and lasting as could be desired?

"In the more profound study of the life of plants, both domestic and wild, we are surprised to see how much they are like children. Study their wants, help them to what they need, be endlessly patient, be honest with them, carefully correcting each fault as it appears, and in due time they will reward you bountifully for every care and attention, and make your heart glad in observing the results of your work. Weeds are weeds because they are jostled, crowded, cropped and trampled upon, scorched by fierce heat, starved or perhaps suffering with cold, wet feet, tormented by insect pests or

lack of nourishing food and sunshine. Most of them have opportunity for blossoming out in luxurious beauty and abundance. A few are so fixed in their habits that it is better to select an individual for adoption and improvement from a race which is more pliable. This stability of character cannot often be known except by careful trial, therefore members from several races at the same time may be selected with advantage; the most pliable and easily educated one will soon make the fact manifest by showing a tendency to 'break' or vary slightly or perhaps profoundly from the wild state. Any variation should be at once seized upon and numerous seedlings raised from this individual. In the next generation one, or several, even more marked variations will be almost certain to appear; for, when a plant once wakes up to the new influences brought to bear upon it, the road is opened for endless improvement in all directions, and the operator finds himself with a wealth of new forms which is almost as discouraging to select from as, in the first place, it was to induce the plant to vary in the least,—now comes

the point where the skill of the operator is put to the severest test. When a wild plant has been induced to change its old habits, fixed by ages of uniform environment, it needs some one with a steady hand to guide it into a condition of refinement and beauty sufficient to adorn any occasion."

One of the rarest flowers Mr. Burbank has ever produced met a tragic fate. It was a most beautiful and delicately tinted flower upon a vine of exquisite greenness, a vine which would be suited admirably for interior decoration or for use in masses upon lawns. It was a hybrid mesembryanthemum, a plant whose habit is to open its beautiful flowers in the sunshine but to close them when the dark weather comes on. The hybrid, while like its ancestors in some general characters, was still unique among flowers, and Mr. Burbank set great store by it. One morning a workman in the part of the grounds where the flower was growing discovered that every plant, wherever it was located — some being in one part of the grounds, some in another — had met simultaneous death at the hands of some mys-

terious enemy, or from some sudden and fatal plant illness; but not a clue had been left and the loss was a very heavy one. The plant could never be reproduced, but fortunately photographs of it had been made.

Many times, however, in the midst of the tests, the foes of the insect and animal world make open war upon the plants, and it would seem sometimes as if with malice aforethought. Some particularly valuable gladioli were surrounded by a row of ordinary gladioli in order to tempt the thieving gophers, should they appear, to satisfy themselves with the coarser bulbs and thus preserve the choice ones. The gophers, however, were not to be put off in any such manner, but passed by the common bulbs and destroyed the rare ones, entailing a severe loss. Mr. Burbank showed me one day a large bed of seedling roses. In one end was a heavy growth of young plants, in the other a space several feet square in which there were not over a half dozen tiny little plants just peeping up through the soil. The plants which had been spared by the birds that had swooped down upon the

plot in an unguarded moment were not specially valuable, but the ones which the birds had selected were very rare and the test was all but defeated. So was it with a new generation of beautiful hybrid larkspurs upon which he had been working for a number of years. The plants were in beds which have wire screens to protect them from the birds, but a workman had thoughtlessly left the screen off and the birds in a few moments wrought havoc with the plants that were more than worth, as Mr. Burbank put it, their weight in diamonds.

There is a constant battle going on against these foes of the plants.

CHAPTER XI

BREEDING FOR PERFUME

WHEN one has come to some appreciation of the wide extent of Mr. Burbank's life-work among the plants of the world, it is not difficult to imagine the flowers gathered in delicate array to make known their individual needs, praying for aid at the hands of one who has never refused them service.

One has length and strength of stem but meagerness of blossom, it is longing for more beautiful flowers;—an answer to its prayer comes in the passing of the years and it grows on and on until it bears a rare, fragrant coronal. One has never been able to hold up its head in the presence of its fellows, bearing its blossoms on a single side of its stem, a sad, top-heavy state;—cannot help be given? As swiftly as may be the gift of grace follows, and now its blossoms surround its stem in radiant beauty. Another has never liked its

color; it would be red where all the centuries it has been golden; a strange little wild beauty would change from the royal purple of a king to the color of the snows upon the mountains; — and they are transformed as by a miracle. A host presses forward from all the ends of the earth;—they are wild, would that they might become tame! And lo! they are changed; they join the fair company of the gardens of the world whose part it is to furnish adornment to those still more fair or to carry their fragrance to the beds of those who lie in pain.

And so it goes among many hundreds of them, each needing something,—beauty, or strength, or hardiness, or length of days,—and the prayer of all is granted.

Ah! but there still remains one unsatisfied: its longing is the most intense of all. It has all that the others have longed for, but it has one sad impairment. It has been doomed through the centuries to bear a most wretched odor, an offense to its fellows, to the world;— if it only could be given some sweet scent like its dear neighbors!

This is the hardest request of all. The

flower has made the greatest demand upon the skill and the resources and the commanding genius of the friend of all flowers.

But even this is granted: a new epoch in the life of the flowers of the earth has come: they need remain scentless no longer.

For twenty-five years Mr. Burbank had been studying the dahlia before he found a way of answering its prayer for relief from its offensive odor; now it is to be freed from its burden. He has driven out the disagreeable odor and, in its place, he has left the fragrance of the magnolia.

The dahlia is a fascinating flower with which to work. Year by year as he studied it and progressed in its development, making it more beautiful, hardier, more interesting in shape of blossom, he brought new varieties into service from other lands to make use of in combination with his own. One of these was originally from Mexico, *Dahlia Juarczi*, the parent of the dahlia now commonly called the cactus dahlia, with petals more on the order of the chrysanthemum.

From the imported varieties he has worked on with the types of his own creation, all the

time building up more beautiful forms. It is interesting to note, in passing, that while the dahlia seeds which he has sent out to leading amateur gardeners in various parts of the world are the ones which he has discarded as not valuable enough to use in carrying forward his experiments,—reserving, of necessity, the very best ones for the work in hand,—yet he has received enthusiastic letters from those who have grown flowers from these discarded seeds, reciting the triumphs won in prizes and premiums at flower shows and county fairs.

The dahlia, like many another flower, when first broken of an old habit of life and led into a new one, finds it sometimes hard to persist in the new way. Everything is strange. It is called upon to do things it never was called upon to do before. A million past tendencies are at work to keep it in the old paths. So, when any new and particularly desirable trait is developed, it is often hard to fix it. And in the fixing of this trait a thousand things must be taken into account,—incidents in its life history, peculiarities of environment, methods of growth and development, individual characteristics.

A bed of the new fragrant dahlias

"To keep track of the details of a plant's life under change from an old order of things," says Mr. Burbank, "and to bear in mind all that must be remembered and considered as to its life history,—beside this, the classification of the botanists is child's play."

When the flower which has been changed in form or color has been watched through a series of years and shows no sign of return to its old ways, then it may be left to itself to follow out the new order of its changed life. It certainly took a long while to make the dahlia double, for example, but this is now a fixed characteristic with no general reversion to the old order.

It so happened one day, several years ago, that Mr. Burbank, while in the dahlia proving-plots, suddenly noticed one flower which bore none of the disagreeable odor characteristic of this plant, but, in its place, a faint fragrance, elusive, but undeniably sweet. Instantly the flower was isolated, and with the most jealous care its seeds were saved and planted.

A problem of immense difficulty was before him, for of all the qualities of a plant the most elusive, the least understandable, the most

intangible, the most difficult to get under control, is that of odor. A thousand and one things interfere to make the problem more difficult. The color of the flowers, the shape of leaves and petals and stem, these are before the eyes and changes in them may be watched and recorded from generation to generation,—but the perfume, no instrument of man can measure or record it: it is the very soul of the flower.

Nevertheless, the more difficult the problem the greater his zest for entering upon it, the deeper his delight in the final solution.

New plants raised from the seeds of this scented dahlia showed a variety of answers to the problem. Some had scarcely, if any, odor, and that not pleasant; some persisted in the full measure of the old disagreeable trait; a very few had some hint of the perfume of the rich magnolia blossom. All but the latter were at once put to death as unworthy to live in the test to follow.

Again the seeds were planted and again the plants were rigidly selected; and so it went on through generations until, one day, there came forth a plant with the full, sweet fragrance of

the magnolia while still retaining all its other good qualities; and then he knew that the battle was won. It might be long until the perfumed dahlia was fully fixed, and longer yet to introduce the new flower to the world, but the chief object had been reached,—the offensive odor had been driven out and in its place had been established a rare and lasting perfume: it was the working of a modern miracle.

"It is not so difficult," Mr. Burbank says of the new scented dahlia, "to teach a plant to transmit other characteristics, and, once its new traits have been fixed, it has no difficulty in keeping on in the new way. When the dahlia once learned to be double, for example, and had had a term of years in which to fix itself in this new form, it was easy enough to go onward in the same way. But it was a new thing for the dahlia to change its odor, it took a long time for it to get used to it. All its life habits through thousands of generations had to be broken up. It was its lifelong habit to bear a disagreeable odor. It was no ordinary thing in its life to make the change; it could not easily give up its old ways. At first, prob-

ably not one out of a thousand seeds produced a flower with any fragrance. It is far easier for a flower to rebel and throw off a new perfume than it is for it to discard some other characteristic which it has been led to adopt."

Now that the solution of the problem has been reached, it is only the question of the necessary time for the conversion of the entire dahlia family to fragrance.

To change an ill odor into a delightful one is one of the most remarkable of Mr. Burbank's achievements in breeding for perfume, but to give a flower fragrance where none before existed, this is a still more difficult task.

For years he has been at work perfecting a heretofore scentless verbena, increasing it in size and beauty of blossoms and giving it a more commanding place among the flowers of the world. In the evening of a summer day, while he was walking in the plots set apart for the testing of the verbenas, a faint odor came up to him on the soft night air. It was so curious a thing, coming from a bed of flowers before bearing no fragrance, that he instantly began a search in the bed for the plant whose blossom had shown this strange scent.

The search was unavailing, however, and a year passed by. Again, in the dusk of just such an evening, he happened to be near the verbenas, and again the ghost of an odor came upward. This time he was not to be denied, and he did not leave the task until he had crept on hands and knees through the verbena beds, discovering, at last, the plant with the subtle fragrance, the faint sweet suggestion of the trailing arbutus, when it comes up in fair, pink beauty through the white snows of the North.

The plant was at once isolated and then began a rigid selection of plants from its seeds, following the same process observed in the dahlia. Year by year the work of selection went on with the utmost care and patience, and year by year the plants showed stronger and gradually stronger traces of the mother odor. At last the fragrance was fixed, greatly intensified in power, so that now it is double the strength of the trailing arbutus and identical with it. The flowers that were scentless have been given a powerful perfume, so firmly established that it will not fade.

It occurred to Mr. Burbank one day that it

would be interesting to give an odor to a calla upon which he was working. Very carefully the plants under test were studied, and at last one was found which bore signs of being a desirable one to use in furthering the experiment. Work was at once begun on it. After years of study and labor he has bred into a scentless calla the odor of the Parma violet, the rarest of violet odors.

One of the many strange incidents occurring all through the work which Mr. Burbank carries on developed while some of the lily tests were under way. One curious lily had gone backward into a sad state of total depravity, as far as fragrance is concerned. It gave forth an odor so powerfully repugnant that the people living in a cottage on the grounds at Sebastopol near the lily bed, found it impossible to endure it. One day before the bed was destroyed, Mr. Burbank was sitting in the sunshine after his luncheon watching a huge buzzard soaring in the blue sky. Suddenly the bird paused in its sweep, poised an instant, and then shot down into the bed of lilies. It floundered around an instant in the bed and then, with, as Mr. Burbank expressed

it, the most disgusted look on a bird's face he ever saw, flew away. While it has long been a mooted question with naturalists as to whether or not the buzzards, vultures and other birds of prey of their class, see, or smell, the carrion which is their delight, the view now held by many leading men is that they depend wholly upon their sight, while Mr. Burbank's experience with his outcast lilies proved in this instance the opposite.

To breed flowers for a certain quality,—beauty, endurance, longevity, hardiness,—this is immensely difficult. It is immeasurably more difficult to breed them for the production of perfume, their subtlest element. Now that Mr. Burbank has demonstrated that flowers may be bred for perfume, that odors may be changed, that scentless flowers may be given fragrance, much work remains for others. It is incredible, the amount of work he has accomplished. He has still larger work before him than any he has ever attempted, and, of necessity, very much that he has under way must be carried forward, as to details, by others. He is never more gratified than when some one else can take

up work which he has begun but which he has not the time to complete, and carry it forward for the adornment or the material welfare of the world.

There is ample opportunity in the breeding of perfumes, as in other departments of his work, for others to go forward in the development of the more practical side. In all the initial experiments, however, this practical side is never lost to sight. He has a poet's love for beauty and he has rare delight in adding to the charm of the world, but he bears along with this the intense practical nature of the shrewdest captain of industry. It is a cardinal principle of Mr. Burbank's never to make a new creation without developing, so far as possible, its practical value.

Speaking of the making of a blue rose,—he has already made a blue poppy,—he said that it was one of the easiest things in the world if one should set out diligently upon it, but it would consume very much time in the making and it would be doubtful, after all, if it added much to the charm of this rare flower. He has studied the rose with great care, and he has seen in the consideration of its coloring an

easy avenue to a land of blue roses. A lesser man would have hastened forward on the road that lead to this strange floral wonder; but, despite the novelty and the fascination that always surround the development of a new creation, he would not enter in upon it when so many greater and more valuable things for the advancement of the world lay before him.

So everything that he does must have, if possible, a definite practical end in view, —it must help the world along.

So in the breeding of flowers for perfume, the paramount thing, from the practical point of view, is to breed the perfume so that it will have a direct, commercial bearing. Mr. Burbank has demonstrated the complete pliability of flowers not only in the way of color and structure but in the way of odor. It now becomes practicable to take a strain of roses, for example, which are prolific and hardy but with little or no odor, and breed into them the most powerful of perfumes. It now becomes possible to take a flower having a perfume not particularly agreeable,—indeed, one positively

disagreeable,—and make its odor a delight. It is also possible to combine flowers of different odors and produce others unknown to the world before.

But, in addition to all this, it is possible, following in Mr. Burbank's lead, to breed flowers with the requisite amount of volatile oil, as it is called, the oil of the plant which enables it to hold its rare sweet scent and from which, when taken from the flower, the perfume is obtained. There are several processes for obtaining the perfume from flowers, but their aim is identical,—to isolate and confine the odor in some form of fat or oil and then dilute it with alcohol into the perfumes we buy at the chemists.

Breeding corn, for example, so that it shall have a certain prescribed amount of fat has been accomplished and made practicable. Indeed, so completely successful is this breeding that corns are prepared with a given per cent of fat for animal or human food, another per cent for the manufacturer of glucose who wants little fat in his corn, another for the manufacturer of corn-oil who wants much fat and little starch.

So with flowers; it is entirely feasible to breed a flower so that it shall have a given amount of volatile oil, selecting through generations those flowers which show increasing amounts of this substance, — determined by analysis, — and by rigid selection and exclusion developing those, as in the corn, which have in their composition the requisite amount of oil for conserving the perfume. It is not always the flower with the most powerful fragrance that is convertible into the largest amount of perfume, but the valuable one is that which carries the perfume most completely in its oil. The odor depends, too, quite frequently upon the quality rather than the quantity of this oil.

Given, then, a flower needing more fragrance, one having no odor but in which it is desirable that an odor shall be placed, one with a disagreeable odor needing change, or one calling for a certain per cent of essential oil to mask its fragrance and aid in converting it into perfume, — they are all to be made over to order.

In the mountains of Bulgaria, where the attar of roses reaches its height of produc-

tion, an hectare of ground,—2.47 acres,—planted to red roses from which the perfume chiefly comes, yields 6,600 pounds of roses in a season. When the perfume is extracted there remain 2.2 pounds of rose attar. This sells on the English market at from twenty to thirty shillings per ounce, about $7.50, which is $300 gross income for the hectare of ground.

Mr. Burbank says that there is no region of the world better adapted for the raising of roses, as well as nearly every other kind of perfume-bearing flower, than California, and that other regions of the United States can produce abundantly many kinds of flowers suited for the manufacture of perfumes. At the present time this country consumes about eight millions of dollars' worth of perfumes a year. The manufacturing of perfumes in the United States has rapidly increased. This manufacture is from pomades or oils containing the scent, and these are made in foreign countries. Now and again sporadic attempts at the extraction of perfume have been made in this country, notably in the case of orange blossoms, but the

amount so produced is as nothing compared with the amount necessary for manufacturing in the United States.

It has been held by some manufacturers that the initial work of producing perfumery could not be carried on successfully in the United States because of the cheapness of the labor of foreign countries. On this point one of the chief manufacturers of perfume in the country says that one of the main reasons why perfumery is not extracted in this country is rather because people pay so much attention to large things in agriculture,—thousand-acre farms and the like, when, in reality, far more money could be made along intensive lines; as, for example, in the line of perfumery production. When told of the work of Mr. Burbank in the breeding of flowers for perfume, he expressed the liveliest interest and amazement,—it was a revelation to him of the possibilities of his own occupation.

Doubtless, this manufacturer stands for others in his belief that the production of perfumery in this country,—the basic pomades from the flowers themselves,—has never yet been attempted on a large enough scale. The

manufacturer was deeply interested, also, in the fact that through breeding and selection the odor in a given flower may be doubled, or even quadrupled, as well as improved in quality.

Some perfumes of much commercial value, as well as of intense pleasure to those who use them, are manufactured wholly from the leaves of plants, and the possibilities in this direction are seen in the new tree which Mr. Burbank has created, the fast-growing walnut referred to in a preceding chapter. The leaves of this tree, which are very abundant, have a most delightful fragrance. While the wood of the tree will furnish fuel and material for furniture manufacture in greater abundance, considering time of growth, than any other tree outside the tropics, the leaves may be made available for the production of a rare perfume,—a commercial combination at once distinctive and of far-reaching significance.

With facilities in the way of climate and soil such as no other nation possesses, and with a native stock to work upon through the labor of Mr. Burbank, unlike anything before

known, the production of this delightful adjunct of the world's pleasure becomes a new source of national wealth.

In this line of Mr. Burbank's life-work, as in hundreds of others, the remarkable acts accomplished are only a part of the complete achievement. Sometimes he has had time to carry forward the work to full commercial ends, but, as the work of his life so magnificently enlarges, much in the way of detail must be done by other hands. He has blazed a central way up through the Unknown, and he has posted signboards at a thousand avenues along the way, telling how this one may be followed to practical success, how that one must be shunned because it leads to failure, how the next road will lead on and on to an open field where harvests of grace, beauty and strength may be reaped.

CHAPTER XII

HARDENING AND ADAPTATION

VERY early in his business career as a nurseryman two facts became apparent to Mr. Burbank:—First, that there were many fruit-growers who paid but little attention to the selection of stock suited to their climate, having the impression that one fruit tree of a given type was as good as another; and, second, that there was a great work to be done in adapting fruits to climates, in aiding Nature to do what she had been unable to do herself.

With this in view, he set out upon an exhaustive study of the chief fruit trees,—not merely a study of them from the botanical point of view but, so to use the word, from a physiological point, to ascertain their full physical characteristics. In so doing he was able to find out precisely what was lacking in a given tree in a given climate and to lead that tree into a closer articulation with its surroundings.

The problems that arose in this line of work were among the most difficult he had ever encountered. Very much had to be taken into account,—the past of the tree, not only immediate but remote, its failures and successes under different environment influences, its limitations, its need of new blood by crossing or the restoration of its depleted veins through selection. For Mr. Burbank had come to look upon all plant life as being very closely allied to the life of man, open to many similar attacks, subject to many diseases, needing the keen eye of the physician and the dietarian, responding to heat and cold, light and shadow, inactivity and exercise. He early recognized, too, the importance of transference, the introduction of a fruit from a distant quarter of the globe, engrafting its life upon the life which was not coming up to its opportunities. He recognized that that which holds true in the human race,—that admixture of blood is desirable, indeed is imperative at intervals, in order to prevent such physical decadence as follows the intermarrying of royal families,—held true sometimes in the vegetable world; there were certain families that needed new blood

from a different quarter in order to restore their slowly ebbing virility.

An illustration of this was seen in the case of trees which would not withstand frost. He took into account large areas of land generally in varying strips running down along the Atlantic seaboard, on by the Gulf of Mexico and even up along the California coast, where certain fruits, as the peach, nectarine and plum, became problematical crops because of the early frosts in the spring. By breeding and selection, choosing for combination fruits from a far colder climate, he produced fruit trees of this type that will withstand absolute freezing in bud, in flower, in infant fruit. Even when the petals of the flower are stiff with ice, they show no signs of wilting when the sun has thawed them out. To make assurance doubly sure, the trees were placed in localities where heavy frosts came early, and they splendidly withstood the freezing.

The value of this work to the world is not within estimate. The proximity of the seacoast regions mentioned to city markets, rendering the production of such fruits at a very early date in the spring a matter of direct

financial importance to growers, is a feature not less significant than the satisfaction of fruit-lovers in these regions at being able to procure much prized but heretofore unobtainable supplies near at hand.

But hardening a plant does not by any means, in Mr. Burbank's use of the word, mean hardening against cold alone. It may be hardening against heat, against the wind, against rain, against drought, diseases or insects.

A most interesting demonstration of the possibilities in these directions was in the case of the gladioli. In California, and in any warm climate with a rich soil below their feet, the old-fashioned gladioli grew rank and tall, and, in case there was, in their blooming season, considerable wind, they were more than apt to be injured or wholly destroyed. So he bred gladioli to withstand wind. Where the stems were from five to six feet tall he bred them down to three feet, at the same time making the stalk much thicker and stronger. This was done by crossing and selection, always choosing those plants which were approaching nearest the end desired until the required length and strength were attained.

Another difficulty with the gladioli was that the petals were so thin and fragile they would not stand the California sun, so he bred with this end in view, producing flowers at last that were thick of petal and able to withstand the heat of the warmest day. In order to accomplish the ends desired, thousands upon thousands of seedlings were grown and crossed and re-crossed in many blendings.

While this work was in progress, he set about another feature which may be mentioned here incidentally, the teaching of the gladioli to bloom around their entire stem instead of on one side, as had been their lifelong habit. After long years of selection, he produced gladioli which have the hyacinth form instead of the old top-heavy form blooming on but one side of the stem. The new flower stands erect, with all its blossoms evenly distributed upon its stem. At the same time he greatly increased the flower in size and in beauty, giving many new notes in the scheme of color.

I saw Mr. Burbank one day walking among a number of his men as they were working on the proving grounds at Sebastopol. They

happened to be setting out tiny plants, new types of berries under test. The long rows were clearly outlined in the earth, stretching like tiny green threads across an acre or two of ground. The plants were set out just as they came from the little square boxes in which they had been raised from the seeds, thousands of them being put out, and as Mr. Burbank came to one of the workmen he said:

"If I only knew which one of all these thousands is the one I want, you wouldn't need to set out any of the rest."

So in all the work of hardening and adapting, if he only knew precisely which ones to cross to produce the results in the shortest possible time, how great would be the saving! But there are few laws to guide when a new creation in the plant world is to be made, and none which will anticipate the end. Bending over a path one day as we were walking through the grounds, he drew a long line in the earth. Then he drew cross lines at intervals.

"There is the scheme," he said. "That long line represents the life of the plant through all its past history. This cross line represents a

break, a sudden, sharp break in its life. I have introduced a new element into the old life. I have broken it up. Henceforth if I keep on breeding and selecting from this new line the old life can never be quite the same again. If the fruit tree, for example, has been for all its history growing in a certain climate under certain practically unvarying conditions of moisture, heat and cold, it must be abruptly changed in order that it shall accommodate itself to new degrees of heat or cold or different amounts of moisture. To what distance I shall carry the plant along its new line depends upon how soon it achieves, and is fixed in, the life I wish it to assume. Very many theories have been held based upon carrying a plant a certain distance. When the point was reached where the plant appeared to refuse to go any further, the conclusion has usually been that this ends it all. This is by no means the case. Plants are sometimes stubborn and need discipline. It is utterly impossible to say that a plant can have only a certain number of leaves, or a certain number of seed-capsules or a certain number of certain other characters. The trouble is that men have

not gone far enough, have stopped when apparently there was no other outcome, but when they were, in reality, only at the beginning, or, at best, in the middle, of their difficulties. It is hard work,—it takes time, it takes patience, it takes persistence, to go on beyond, but is it not worth it?

"Now and then the limit appears to be passed and the theorist says, 'Ah, but this is only an abnormality, a monstrosity.' Yes, but is it? How does he know it is? How does he know but that the very abnormality may not be followed and helped and developed until it becomes a splendid norm, reproducing it again and again and again, strengthening it where necessary, but all the time pressing it forward and finally fixing it? How many normalities have we now in plant life that were not, in one sense, once abnormalities?

"In hardening a plant from cold, it is generally best to select for stock upon which to work those plants which have naturally the hardiest bulbs, the hardiest leaves, and the hardiest wood,—generally, I say, though not always. An arctic plant which may have all these characteristics may prove very valuable

for blending with a plant long accustomed to the warmer portions of the temperate zone. Then, by uniting this arctic plant with the temperate zone plant, I reach a plant which is of the right frost resistance to be grown in the colder parts of the temperate zones, and thus are made possible these frost-resisting fruit trees which will bear stiff freezing without harm. Another plant may be troubled with cold, wet feet—it needs hardening so that it will grow satisfactorily in a soil that may be wet. So it must be bred against this. One of the arctic plants, for example, which has never grown in the temperate zone may be a very desirable plant to introduce, but it has never been used to a warm, early spring and it begins its budding and blossoming so early that it fails to accomplish what it should in fruit or flower productions. So it is necessary to breed it in turn to temperate climate conditions.

"Cross a hardy plant and a tender plant and often the tendency is toward the hardy; the waves, so to speak, sweep ever up toward the hardy, to the highest limits of the hardy, and some few sweep up over;—it is these few we must catch and make use of, for, on an

average, the waves will go no higher than the point of greatest hardiness. Thus, as the work progresses, the plants which now and then show peculiar hardiness beyond the normal are chosen to carry forward the tests. From these very hardiest ones, after long breeding and selection come the ones which are not only to unite the desirable qualities of their forbears but which are to be fitted for their new environment."

But in addition to hardening plants against all these—sun and ice and drought and rain,—they must be hardened for shipping and allied purposes. Mr. Burbank may have a fruit, for example, which matures early, is of a very desirable character aud would sell well at a long distance from its point of production. But it is too soft—it will not stand shipment. So he puts it through a long course of training, so to speak, and, when he is through with it, it will bear the long shipment and come out at the end of the journey as fine as when it started.

In the production of the prune, the outer skin has an important bearing upon the success of the industry. After the prunes have been gathered and graded in size, they are

dipped in a weak solution of lye, in order to thin and crack the skin, to enable the moisture easily to escape when the drying process comes, thus preventing fermentation. After they are dipped they are placed in the sun to dry or, in regions where there is not sufficient sunshine, in machine driers. Some prunes have so thick a skin that they require far too much lye treatment, some are so thin that they burst open under the treatment and are thus destroyed for regular prune packing. Mr. Burbank has obviated this difficulty by breeding a prune with a skin so delicately veined and so susceptible to the solution that it needs but a trifling dipping to crack in fine thread-like lines and thus permit the escape of the moisture. This new prune, by thus having its skin bred to precisely the right thickness, must supplant other prunes, either too thick or too thin or too variable.

The extension of this line of Mr. Burbank's work is practically limitless. DeVries, the Dutch botanist elsewhere referred to, commenting upon the extensive work of Mr. Burbank, says:

"Specialization with him is not the limit-

ing of the number of genuses and species, but in the analogous method to which he submits all of them. And so this method is by him carried to the highest degree of perfection, while at the same time the results are so immense that they receive the admiration of the whole world. His plums and prunes, adapted for canning and drying, have a quality and a productiveness such that, in spite of the cost of preparation and the expense of transportation, they are competing with splendid success in Europe with the kinds there cultivated and are a source of revenue for large stretches of country, which they carry up to a hitherto unknown state of prosperity. The production of such varieties, therefore, has the greatest direct influence upon the growth and progress of agriculture and horticulture. It promises work for thousands of people and to the most enterprising amongst them it gives a chance for the rapid acquisition of wealth."

This appreciation on the part of one of the foremost scientific men in the world is in direct line with the appreciation which Mr. Burbank receives in letters from practical fruit-growers from all over the world.

But a singular situation is suggested by the possibilities of this adaptation. One of the leading fruit-growers of northern California, an ardent admirer of Mr. Burbank and largely interested in the production of some of his new fruits, makes the point that, in spite of the great work Mr. Burbank has done and is doing, for the development of fruit-culture in California, the supremacy of California as a fruit-producing state is eventually to be threatened, because of the fact that Mr. Burbank is adapting so many of the fruits, now grown in California extensively, to other regions of the country. Thus, if he makes a pear so hardy that it will grow in a climate where pears have never been grown successfully before, or in like manner hardens a peach, a prune, an apricot, a plum or a cherry, the fruit-growers of that region will be swift to adopt the new fruit. They will at once be given an immediate market; their customers will be delighted that they can get the choicest fruits at their very doors and filled with pride that their climate is no longer to be pronounced inimical to fruit-raising; while a new and profitable industry springs into life.

Mr. Burbank is a loyal Californian, but he is also loyal to all the fruit interests of the world. From his own eatholic point of view his mission among men is to do the greatest possible good to the greatest possible number of the race.

The following, bearing directly upon the subject of adaptation of fruits to other regions, is the opinion of a practical fruit-grower of California:

"Mr. Burbank is doing for the East in plum culture, what Hale and other peach-growers have done for the peach crop. He will increase it ten-fold, perhaps a hundred-fold, and deprive California, to that extent, of a market for her plums. California ships millions of boxes of plums to the eastern markets annually, and the business is highly profitable. Now comes Mr. Burbank and creates new plums by the dozens, that bear enormously and live and thrive equally well in the frozen North, the sunny South or the favoring climate of California. Is it not possible that the California plum market will go the way of the peach market after Mr. Burbank's plums shall have been sufficiently grown in the East? Of

course, this will not worry Mr. Burbank, for he is a citizen of the world rather than of California. His avowed purpose is 'to make the very best fruits and nuts an every-day food for all, instead of an occasional luxury for the few.' No doubt the world will be benefited, although California's present favorable position in plum culture may be shaken."

CHAPTER XIII

ON THE ORIGIN OF NEW SPECIES

SHOULD a dweller upon some other planet where some other sun kisses its earth into life come down through space bearing a fruit as yet untasted by the world-men, it would not be more distinctive, or more delicious to the taste, than the fruit which Mr. Burbank picked one summer day from a tree which he had made from three other trees. For the fruit which he picked was unlike any other fruit which had grown on the earth before—it was absolutely new, he had accomplished that which men had said was impossible. So it has been said on other occasions,—such and such things cannot be done. Mr. Burbank says, Wait; let us see about it.

He took a wild American plum, a Japanese plum, and an apricot. He bred these three together and made a third, the plumcot, different in texture, color and taste from any other fruit. Not only did he thus create a

new fruit, adding much to the dietary of the nations, but in this, and a number of similar instances, he has opened the way to an indefinite extension of the same principle—the creation of fruits which shall supplant or supplement old ones. Indeed there are now opened in many lines of plant life, by this demonstration of the feasibility of creating new species, possibilities whose scope is limitless.

The plumcot by some might still be pronounced only a variation or combination of similar species,—though, as will be seen later, even this objection will not lie against the primus berry and the phenomenal berry. And yet, when two such absolutely different, even if allied, fruits as the plum and the apricot are bred together, producing a third and absolutely new fruit, it is quite difficult to see wherein this is not a new and distinct species.

This new fruit is not only delightful to the taste but it is very interesting in its character. Sometimes the flesh will be yellow, sometimes pink, sometimes white or crimson. Sometimes it has pits like the apricot, sometimes like the plum. The fruit is highly colored, maintaining the prevailing hues of the apricot. The

The plumcot, created from the plum and the apricot. A rare new fruit

The "Climax," one of the rarest plums produced

flavor of the new fruit is indescribable, as unique as it is delicious.

The new fruit was produced in the usual way, the three basic fruits being inter-pollenated so that there was a thorough blending or crossing of them all. Then selection was made from the crosses until at length, after years had elapsed, after prolonged and most patient testing, the new fruit was produced. There yet remains further work upon it before it shall be given to the world, but its place in the world as a new and distinct type of fruit life is now assured. Mr. Burbank began this particular experiment in another line, the crossing of a plum and an almond; then branching off into the plum-apricot line as promising more satisfactory results. The plum and the almond combined in a sense, producing some spectacular plant effects, but the union did not promise results worthy of further work, so it was dropped.

Other curious combinations have from time to time been made, with results not yet fully determined in some cases. A raspberry and a strawberry were united. Strange results developed. The plants were curious indeed. The

plants were entirely thornless, absolutely and invariably persisting in the strawberry characteristics. They bore leaves, but instead of having raspberry leaves, as would be natural to go with their long stems, the leaves were all trifoliate, a regular strawberry leaf. Under ground, the plant sent out long branches, or stolons, precisely as the strawberry plant sends them out above ground. These stolons bore plants, and when they came up they took on the length of stem of the raspberry parent, growing from three to five feet in height. Flowers came in great abundance, three or four times as many as the raspberry, seven or eight times as many as the strawberry. But the plant was foredoomed, for it bore no fruit. Flowers came in abundance, indeed, lived their allotted time, and dropped to the ground, but the only fruit, or approach to a fruit was a little knob where the fruit should have been, a very travesty of a berry. Hundreds of these plants were grown.

An apple was crossed with a blackberry. The plant which followed was apple so far as foliage and general character were concerned, although in the thickness and general charac-

ter of the leaves the blackberry influence was unmistakably apparent. Strangely enough, the blackberry seeds which came from the cross produced the apple-tree growth. Four to five thousand trees were thus grown, all practically identical in character. All but two of the cross refused to fruit, though almost all of them blossomed abundantly. Some of the blossoms were rose-colored like the apple, some of them almost crimson. Nearly all were thornless.

A black raspberry was crossed with a blackberry, with the result that most of the product of the union died just as fruit-bearing time came on. Many hybrids, Mr. Burbank notes, die when it comes to the age of reproduction because, for one or another reason, the stamina of the parents is exhausted and the act of fruit production proves too great a strain. The mountain ash and the blackberry were also crossed, resulting in a salmon-colored fruit, the bush bearing no thorns. Many combinations of peaches and almonds have been made, further tests in this combination now being under way. In the proving grounds at Sebastopol there stands a row of these peach-

almond crosses, raised from seeds. The great difference between seedlings is shown in this row. One peach-almond tree is six to seven inches in diameter at the base, with branches running from two to four inches thick where they leave the trunk. The tree is perhaps twenty feet high, with a large spread of branches. Directly alongside are several peach seedlings of the same age. Their trunks are not thicker than the branches of the other tree and they are not over six feet in height. They are poor and scant of foliage as compared with the others. The peach-almond combination generally produces a pit-nut, so to call it, which has the outside character of a peach pit, and inside the thin inner shell of the almond. Sometimes the flesh of the hybrid fruit that has come from the cross has been too thin, sometimes there has been too much stone. The final results of this cross will be looked for with great interest.

Many other combinations have been made. No one may tell what inter-combination of these crosses might have accomplished if the breeding and selection had been pushed further. But when Mr. Burbank finds that a

The Phenomenal berry, a new species of great size and richness. Individual berries are sometimes nearly three inches long

union of two diverse fruits does not within a reasonable time satisfactorily respond, he drops it, even though it may hold out ultimate possibilities.

But important from a scientific and practical point of view as the plumcot is, it is overshadowed in scientific interest, in a sense, by the "Primus" berry. This was an absolutely new species of fruit, the first known recorded species directly created by man. The primus berry was made from the native California dewberry and a Siberian raspberry. The two were crossed by pollenation for the purpose of developing, if possible, a distinct new fruit. Seedlings raised from Primus always produced true like a wild species, even so that if found wild all botanists everywhere would classify it as a true species. In general very many species are drawn upon. For example, he has worked upon over forty different blackberries gathered from all over the world to produce from among their many crosses new hybrid types which should be better in various ways than any of the ancestors,—larger, finer of flavor, more beautiful, better to ship. But in this particular test though difficult problems

were met he kept up the work thus to the end. The merging of the dewberry and the Siberian raspberry was complete. The fruit was unlike either parent in form, color and taste. There were no abnormalities. The flowering was fine, the fruitage large and natural, the foliage normal, the persistence absolute. Several years were allowed to elapse before the new fruit was put upon the market, in order to fix its new life habits, to make sure that it did not break away or return to some of its old ways. The flavor of the berry was neither that of the dewberry nor the raspberry, it was unique and most delightful to the taste of most people. It ripened its main crop at the same time with the strawberries and continued to bear more or less all summer. Its fruit ripened long before most of the standard, well-known kinds of raspberries and blackberries had begun to bloom.

One curious feature of the new fruit, and one which seems specially significant, was that nearly all the other seedlings which grew from the same cross were absolutely barren. They blossomed abundantly and the blossoms of many plants seemed perfect, but Nature

refused to grant fruitage to any of them. Strangely enough, too, the new berry upon which Nature bestowed its favor ripens its fruit several weeks earlier than either parent and excels both in productiveness.

In planting over five thousand seeds of the new berry, every one produced a primus berry, with such slight variations as may be observed in seedlings of any other fixed species. This added the last needed proof, if other proof were necessary, showing that amalgamation had been complete.

By all scientific rules and tests, as well as by the canons of common sense, the primus berry takes its place with the plumcot and the phenomenal berry as distinct new creations. It should be noted, however, that not every plumcot seed planted produces a plumcot, thus fixing it also as distinct. Some slightly incline to one parent, some to the other, as not enough time has elapsed completely to fix the type.

After the creation of the primus berry came that of the Phenomenal berry, in itself as wonderful as either the plumcot or the primus berry. It was the result of the union of the California wild dewberry and the Cuthbert

raspberry, a complete cross, producing an absolutely new berry, larger than the largest berry ever before known. Each plant produces annually eight to ten stalks or canes about twelve feet in length. The berries are very large, light to dark crimson in color, and grow in remarkable profusion.

Very many other crosses have been made with varying results, embracing:

Peaches and almonds, peach and chicksaw plum, almond and Japanese plum, apricot and Japanese plum, Chinese quince and common quince, quince and crab-apple, Japanese quince and apple, potato and tomato, apricot and peach, domestic plum and wild goose plum, wild crab-apple and common apple, quince and apple, nicotiana and petunia, rose and apple, hawthorn and blackberry, quince and blackberry.

Speaking of crossing and selection in general, Mr. Burbank says:

"There is no barrier to obtaining fruits of any size, form or flavor desired, and none to producing plants and flowers of any form, color or fragrance. All that is needed is a knowledge to guide our efforts in the right direction,

undeviating patience, and cultivated eyes to detect variations of values."

The production of these three new and valuable species of fruits is not only of great interest and large economic value, but it opens the way to an indefinite extension. Here, as in many other lines, much work remains to be done by other hands. Within certain limitations there remain vast opportunities for the production of other fruits, of grains and grasses and trees and all manner of plant life now unknown to the world. Not only is novelty to be looked for, but important additions to man's resources. If a combination of certain grains, for example, could be made producing a wholly new grain of augmented food supply and productivity, the importance of the product to the world would be beyond estimate.

Such creations as these Mr. Burbank has effected, with many other improvements upon old forms of plant life, establish anew the fact that the time which has been predicted by some pessimistic theorists, when there will be too many people on the globe for the productivity of the earth, must be set forward so

many ages as to leave no further cause for even academic apprehension.

It is of interest to note that, in the progress of these and other experiments, Mr. Burbank demonstrates the fallacy of another scientific statement. It has long been held that, under certain conditions, the progeny of a given plant union would be affected in a demonstrable way by one or the other of the parents, the parental life fixing itself in certain positive and indelible forms upon the child life. In the midst of vast experiments where he has had unrivaled opportunities for studying every phase of plant life, Mr. Burbank has again and again demonstrated that this power, prepotency as it is called, simply depends upon heredity and that there is no prepotency of male or female as such. Other things being equal, he says it may be set down as fixed that there is absolutely no balance in favor of either sex, as sex. Upon this point Mr. Burbank says:

"In grafting, every conceivable stage of congeniality between stock and graft is found, from actual poisoning to refusal to unite; uniting and not growing; or growing for a short

time and dying; or separating where united; or bearing one or two crops of fruit and then suddenly blighting; or separating after years of growth up to complete congeniality. So it is in crossing,—all grades of hybridity are to be found. Crossed plants generally have the characteristics of both parents combined, yet sometimes show their parental influences on one side, producing uncertain results in the first generation. In the second and succeeding generations these cross-bred seedlings usually break away into endless forms and combinations, sometimes reverting to some strange ancestral form which existed in the dim past. Or the break may not occur until after many generations. But when once the old, persistent type is broken up, the road is open for advances in any useful direction. Sometimes hybridized or crossed seedlings show considerable, or even great, variation for weeks; or they may show no change in foliage or growth from one or the other parent form until nearly ready to bloom or bear fruit, when they suddenly change in foliage, growth, character and general appearance."

This question of the origin of new species

has been of absorbing interest to those scientists who have visited Mr. Burbank. DeVries, already referred to, had for years been developing the theory of mutation—elsewhere noted in connection with Mr. Burbank's theories—but when he came to see the wonderful results that Mr. Burbank had achieved on so great a scale he was impelled to write thus:

"One of the most marvelous features of Burbank's work is the immensity of the number of his different seedlings. This is a powerful principle, to reach in a short time such very important variations. The rule is: Thousands of seedlings for each hybrid. . . . Half a million lily bulbs, a result of one crossing through thrice repeated crossings and selections, were entirely destroyed after fifty of the best bulbs were selected for further culture. And so I might cite all kinds of examples.

"Every one understands that the chance to find something good is greater if it can be made from several hundred thousand than from only a few hundreds. Those who wish to compete with Burbank must accept this principle, and, if this cannot be done, must

Variation in hybrid poppy leaves. Out of two thousand plants no two were alike

choose a different way or else choose species which require or admit a different method.

"Theoretically, however, it is of great importance to compare this principle with the method of selection generally in vogue in Europe, where they do not work upon such a large scale. In Europe the preference is given to repeated selections, with the idea that the desired results may be reached by going the regular road. If they wish to increase the size of a flower to a stipulated limit, they do not sow at one time great quantities, as does Burbank, but a great deal less and pick out the largest to raise from. On the progeny raised from that seed the same process is followed, and so in four or five years the desired result is reached; at least if the desires are limited to the possible attainment.

"The theoretical question now is: By such a repeated selection do we proceed faster than by a single sowing out upon a much greater scale? With five years' labor we have to cultivate so much fewer that the expense would thereby be lessened in proportion, but against this plan comes the disadvantage very naturally that the results would only come in so

much longer time. . . . I would not put the question if it were not of so great importance in the study of etiology. It is very closely connected with the question whether one must accept a slowly merging in one another of species, or that one produces the other by jumps. (The pith of DeVries' *Mutationis theorie.*) In the first place, small deviation would increase in the course of the generations, and long series of intermediate forms would connect the new with the old. In the second case, however, the jump would be made at once, without any intermediates."

This was written in California by DeVries before he left for his home in Holland, and the very night following his visit to Mr. Burbank. He had long advocated the mutation theory earnestly, as elsewhere noted, but in the results of Mr. Burbank's vast experiments he was confronted with facts he had never known before. Hence the following:

"So long as there were no sufficient examples of this manner of change and we had to rely upon spontaneous varieties in horticulture, the first proposition was the most probable. It rested upon several experiences

in horticulture and garden culture in relation to the improvement of the species, and it was accepted that the species had been produced in a similar way. At that time we were unacquainted with the results of sowing on such a scale as that of Burbank, and we imagined that the results could be reached only by repeated selections. However, it is clear that this view would lose a great deal of its meaning if by experiments upon a large scale the variability could be reached at once; that which we imagined previously could be reached only by slow degrees."

Dr. de Vries again mentions the fact that the scale of Mr. Burbank's work excels everything that was ever done in the world before, and then describes the production by Mr. Burbank of the new species above referred to,—the primus berry, the first fixed species ever recorded made by man. As is noted elsewhere, Mr. Burbank has produced the mutations or changes which have been considered to have such an important scientific bearing, at will.

Now that it has been established, despite the dictum of the older scientists, that two variant

species may be made to combine and produce a new species wholly unknown to the world before, who shall predict what may be accomplished for the world along this line? Limitless fields of material progress are thus opened for all future plant-breeders, vast possibilities for the adornment and the enrichment of the earth. If a man deserve lasting credit who causes two blades of grass to grow where but one grew before, what shall be said of one who, beyond all else he has accomplished, has added new life to the vegetable kingdom and opened thus a thousand avenues to others? New fruits, as yet untasted by man, fruits of the vine and the shrub and the tree; new grains, new grasses, new trees, new flowers are to appear along the paths he has blazed through the regions of the Unknown.

In the great depths of the ocean, the abyssal depths, some miles below the surface, many strange forms of life are being brought to light by the deep-sea dredging of the biologists. Among the lowest forms of life is one where animal and vegetable life occupy the same house, so to speak, and intermingle in most curious fashion. The animal life lives upon

the plant life and the plant life upon the animal, each subsisting in certain measure upon the waste of the other. It is a composite, so to speak,—half animal, half vegetable.

Looking to the future, and taking into account what Mr. Burbank has already accomplished in the creation of new life, will it be possible, granting the common protoplasmic basis of plant and animal life, eventually to interblend the two? Such union, should it come, must be scarcely more marvelous than the union here recorded, effecting creations which Nature, in the very amplitude of her powers, never could have achieved alone.

CHAPTER XIV

HOW MAY I DO IT TOO;—BREEDING

IN a certain negative sense the most wonderful thing about Mr. Burbank's work is that there are absolutely no secrets. He is as open as a book. He is not only peculiarly frank and ingenuous by nature, but he carries the same attributes into all conversations that arise pertaining to his great lifework. He is never happier than when he is doing something for some one else. Unselfishness fits him as a garment, but there the figure must change; for it fills all his life. So when it comes to showing others all that can well be shown of his work, he is supremely happy.

The unfortunate word "wizard" attached itself to him when some of his remarkable achievements first became known, a term which he has always resented, as he has always deprecated those efforts of over-enthusiastic friends who have sought to weave strange

mysteries about him. The marvel does not lie in the methods, but in the man.

At the same time, there is very much of interest in the details of these methods, first, because he has practically thrown aside all precedent when it in any way conflicted with his own judgment; and, second, because he has always been not only willing, but anxious, that others should know all that he knows, in order that the widest possible good might come to the world. Not that any one may hope to achieve results of similar importance merely by adopting his methods,—for only another such a man will ever do what he has done,—but he opens the door and asks any one in who has a mind inclined to do service to the world.

Mr. Burbank thus speaks in general terms of plant-breeding:

"The foundation principles of plant-breeding are simple and may be stated in a few words; the practical application of these principles demands the highest and most refined efforts of which the mind of man is capable, and no line of mental effort promises more for the elevation, advancement, prosperity and

happiness of the whole human race. Plant-breeding is the intelligent application of the forces of the human mind in guiding the inherent life-forces into useful directions by crossing to make perturbations or variations and new combinations of these forces, and by radically changing environments; both of which produce somewhat similar results, thus giving a broader field for selection, which again is simply the persistent application of mental force to guide and fix the perturbed life-forces in the desired channels.

"Plant-breeding is in its earliest infancy. Its possibilities, and even its fundamental principles, are understood but by few. In the past it has been mostly dabbling with tremendous forces, which have been only partially appreciated, and it has yet to approach the precision which we expect in the handling of steam or electricity. Notwithstanding the occasional sneers of the ignorant, these silent forces embodied in plant-life have yet a part to play in the regeneration of the race which, by comparison, will dwarf into insignificance the services which steam and electricity have so far given. Even un-

conscious or half-conscious plant-breeding has been one of the greatest forces in the elevation of the race. The chemist, the mechanic, have, so to speak, domesticated some of the forces of Nature, but the plant-breeder is now learning to guide even the creative forces into new and useful channels This knowledge is a priceless legacy, making clear the way for some of the greatest benefits which man has ever received from any source by the study of Nature.

"The plant-breeder, before making combinations, should with great care select the individual plants which seem best adapted to his purpose, as by this course many years of experiment and much needless expense will be avoided.

"The plant-breeder is an explorer into the infinite. He will have no time to make money, and his brain must be clear and alert in throwing aside fossil ideas and rapidly replacing them with living, throbbing thought followed by action. Then, and not till then, shall he create marvels of beauty and value in new expressions of materialized force, for everything of value must be produced by the

intelligent application of the forces of Nature which are always awaiting our commands. The vast possibilities of plant-breeding can hardly be estimated. They are not alone for one year or for our own time or race, but are beneficent legacies for every man, woman and child who shall ever inhabit the earth."

Much of the preliminary work in Mr. Burbank's plant-breeding is carried on at Santa Rosa, where his home is located. He lives here in a small, old-fashioned, two-story frame house, with an immaculate front yard and four acres of testing-grounds to the rear. Near the dwelling is a small greenhouse where certain tests are all the time under way, particularly those in which the plants require forcing in order to hasten the work. In the rear of the greenhouse stands his packing-house, the upper portion being given up to storage. Here are thousands of paper sacks and boxes containing all manner of seeds, roots and bulbs, many of them in the midst of tests, many of them finished products priceless in value.

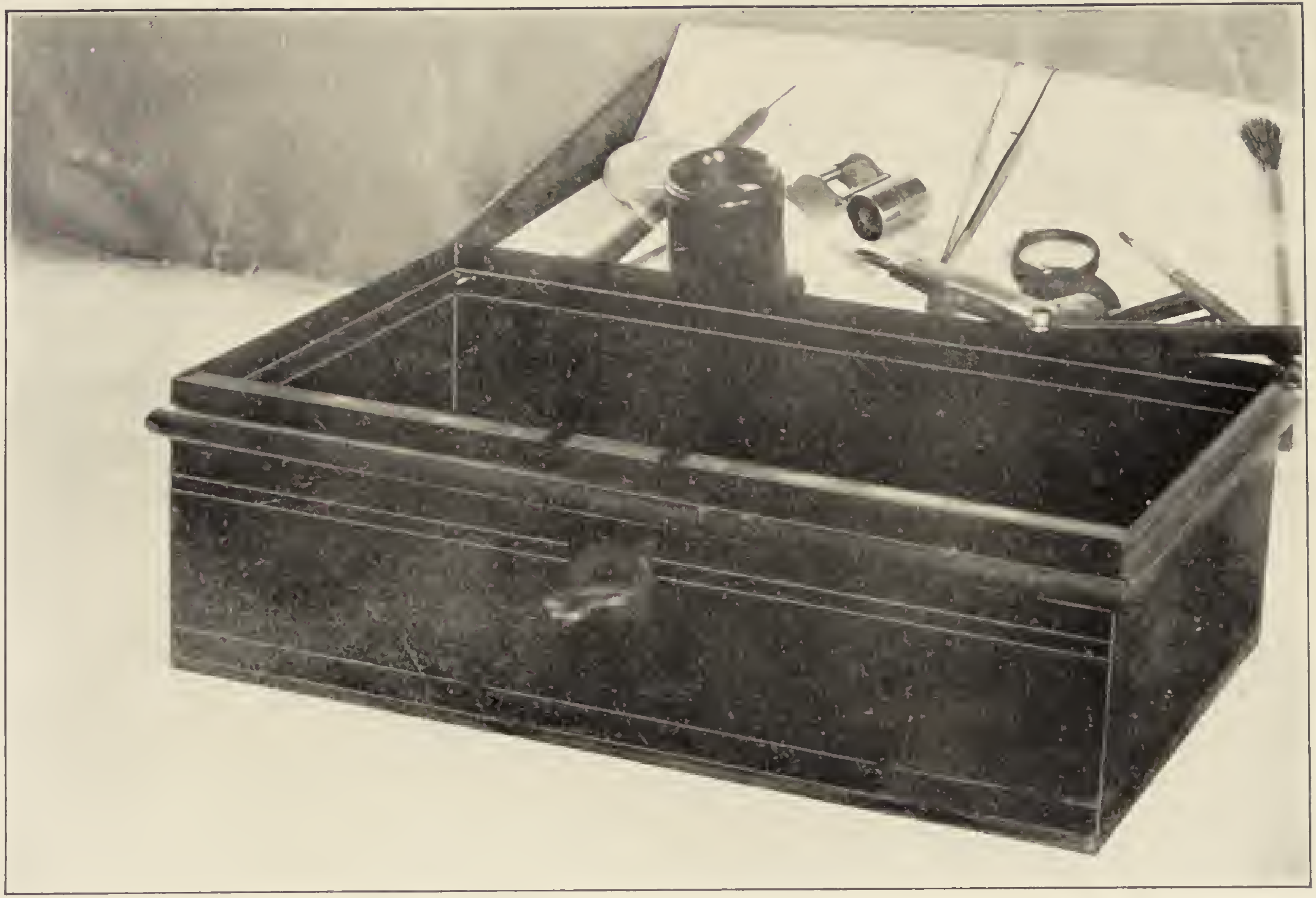
The open ground in the rear of the house and barn is divided off into beds of different

sizes. Some of these are perhaps fifty by a hundred feet, some four hundred by twenty feet; others, enclosed in frame borders, are from six to ten feet square. Wire screens are prepared to be adjusted to these smaller beds in order to keep out the birds. Millions upon millions of seeds are sown in these plots of ground every season, and, from the plants that grow, rigid selection is constantly going on.

Workmen are always to be seen about the place, quiet, clear-eyed, intelligent men, trained men, whose hearts are in the work. Every morning they take their orders from Mr. Burbank for the day, and carry them out quietly but enthusiastically. No man ever had more loyal aids; they are not only attentive to their work, but they are devotedly attached to the quiet man who goes in and out among them all so gently, but who, if occasion demands, can give a command no workman would dare ignore, or deal out a denunciation of a misdemeanor exceeding bitter to the taste. It is rare, though, that he ever gives rein to his words when satire is in the saddle, but when he does, the pace is swift and the rider holds a whip of scorpions.

The climate of California is particularly favorable to his work because of the length of seasons in which tests may be carried on,—a perpetual season, in fact, for some lines of the work. On one day you may see one plot of ground filled with a mass of flaming poppies: at another time it may be white with lilies, or it may be crimson with the royal amaryllis or blue with larkspurs, or purple with some little wild flower—it is never twice alike. When one test is ended, the plants are dug up and burned and the ground made ready for the next experiment. Whenever the soil begins to show signs of running low in nutriment, fertilizers are used to restore it. But all this is taken into account, for the finished plant must go to the world equipped for general, normal condition of soil and climate.

As has been noted in the chapter on the general methods, breeding and selection are the basic facts in all this work. When the flowers of a given test are in full blossom the work of pollenation begins. For this work, when it presents only general problems, Mr. Burbank relies almost entirely upon his finger-tips. He does not recommend that an ama-



An outfit for an amateur breeder

teur should so restrict himself, but suggests various instruments: A pair of jeweler's forceps, or pincers, a jeweler's eyeglass, a small but powerful microscope, a sharp knife, a saucer for holding the pollen, a soft brush for sifting or dusting the pollen from the saucer to the stigma of the plant to be fertilized.

Whenever it is necessary, he makes use of any or all of these, or of other devices of his own making, but chiefly he pollenates by securing the pollen upon a watch-crystal and placing it upon the stigma with his finger-tips. The main object is to see that the pollen from the one flower gets onto the stigma of the other flower. The fertilizing, or fructifying, Nature will do herself if man has done his work well.

Sometimes there are flowers which Nature has in her own good ways made extremely difficult to pollenate, flowers for which strange devices and curious contrivances and traps are prepared by Nature in order to get certain insects,—and only those,—to enter the flower at just the right time and there to hold them captive until they deposit the pollen they have gathered from another flower. Of such plants

as these Mr. Burbank makes a very careful study, supplementing Nature where necessary, tenderly outwitting her, if needs be. Sometimes he cuts away the petals, stamens and sepals entirely, so as to form an unattractive and inhospitable place for the insects in order that they may be kept out entirely. Strategem plays no unimportant part in this work. Now and again in order to produce a given result, fully nine-tenths of the flower buds will be cut away in order to force the other one-tenth to produce a stronger development.

But Mr. Burbank does not recommend any difficult problems for the amateur; rather, he insists on the very simplest ones to begin with. He places confidence, the confidence which comes from having accomplished something, as the initial essential. Failure, he says, leads to disappointment, and disappointment to discouragement, and discouragement is own cousin to despair. So he says: Confidence born of success is imperative in amateur plant-breeding.

And to this end he urges taking up a single flower to begin with, never a composite one. He recommends for crossing, the sweet peas,

geraniums, petunias, Japanese pinks or violets. These will do to begin on, though there are many others. He recommends for selection alone, the pansy and the sweet pea as offering opportunities of unusual promise. Of course all of the flowers mentioned, and in fact every flower whose life is to be changed in any respect, must come under the most rigid selection, the eternal choosing of the best.

When a certain flower, say a sweet pea, has been decided on, the pollen from one of the two that are going to be crossed in order to give birth to a third that, it is hoped, shall be better than either parent, is gathered upon a little saucer or a watch-crystal, taken to the flower which has been chosen as a mate, and dusted down upon its stigma. Then this latter flower should be isolated from its fellows and guarded carefully. A paper tag should be fastened to it for identification. Mr. Burbank says to watch the bees, and when they are first a-wing upon their day's work, be sure the flowers are ready to be pollenated.

He says that it is wholly unnecessary in ordinary plant-breeding to attempt to cover the flower with a screen of tissue paper or gauze.

This method has been followed by some in the belief that they were thereby preventing insects from coming in and destroying the pollenating, but he holds that, save in some particular cases, the act is not only absurd but absolutely harmful and more than likely so to injure the flower by keeping light and air away from it as to frustrate the very end aimed at. If the pollenating has been thorough, Nature may safely be left to do the rest.

Great care also should be exercised in saving the seeds of the plants under test. He recommends air-tight glass jars for the purpose. The jars should be kept in some secure place—it is beyond the power of any mind to say how precious these seeds may prove to be.

From the plants that grow from the new seeds one only should be chosen, the very best of all, the one which is the thriftiest, the best bearing, the nearest to the ideal. The seeds from this one plant should be in turn planted, and then from a very few of the very best plants enough plants saved out to insure a somewhat larger crop for the next generation. Then from this larger generation only the very best one should be saved. Mr. Burbank

lays special stress upon this,—to save only one and that the very best of all; no matter if there be a hundred plants or a thousand, save only the very best.

Naturally one who has been long expert at the work will be able easily to choose a good many plants of relatively the same value in order to secure quicker results as a test proceeds; but, even then, when the final test of all comes, there must remain but one as the basis of the world's stock.

So on and on from year to year the work should go, the best plant of each succeeding generation approaching nearer the end sought until, a fruit or flower is produced which reaches, which may indeed surpass, the model set before the mind.

One may have, for example, a certain variety of sweet peas which is not exactly to one's liking,—make them over to suit you. If the stems are too long, shorten them. If they are too short, lengthen them. If the blossom is not large enough, make it larger. If the color is pink and you want it red, teach it to take on the crimson hue. Pick out beforehand, is Mr. Burbank's advice, the particular improvement

you wish. Fix this firmly in your mind, and constantly select with this end in view. And be not led astray from it by some other interesting manifestation of the flower; or, if something unusual does develop, side-track this for further test, and keep on the main track, doing all faithfully, consistently, enthusiastically, and the desired end will come. It must be ever borne in mind that only those plants must be kept which are pressing onward toward the ideal. All the rest must be destroyed, or else they will be liable to mix with the ones under test and thus lower the standard.

Naturally, the more extensive botanical and historical knowledge one has of a given plant under experiment, the better,—its habits, its former environment, its needs as to soil, amount of moisture, preference for sunshine or shade, and so on, its complete life history.

For crossing first and then selection, he places the violet among one of the very best as the flower now offering to the amateur one of the finest fields for experimentation. It is somewhat more difficult to cross than some of the others, but still, with a little patience, may

be mastered. He says that remarkable results await the plant-breeder in producing better violets—larger, deeper in tone, different in color, stronger in perfume.

Varieties of pansies are already so numerous that he would waste no time in trying to make new combinations of them, though they offer a fascinating field for selection, in making them larger, more intense in color, more velvety in texture.

Another point on which Mr. Burbank lays emphasis is that the beginner should at the outset treat one flower alone, not spread out too much. Later on, when he has become familiar with the work, he may have as many varieties under test as he may have time to care for; but, at first, deal with but one. While the general work is simple in its character, there are always many minor problems which will come up for solution, and the more numerous the problems the less likelihood of the initial success upon which he places so much emphasis, a little encouragement at the outset is of paramount importance. To be able to show your friend a flower which you by your own skill and patience have re-

created, presenting certain features which this particular flower never before possessed, is not only something for mutual pleasure but a distinct floral triumph. It may be, indeed, you have set the pace for the whole world.

But crossing old plants or creating new ones is not child's play. To do it successfully requires intelligent effort, the highest judgment, the soundest common sense, patience of no ordinary type. The man who has a small plot of ground,—it may be only a few square feet of ground in a cooped-up city back yard, or, indeed, it may be he is driven to a few feet of earth upon his roof for his gardening,—usually does not have much spare time for such work, even if he has a love for flowers and loves to have them upon his table, but even this circumscribed man may accomplish some remarkable results. If he has a larger garden in the country town or suburb, or if he be fortunate enough to be one of that class of well-to-do people who are learning in the dear school of experience that, with all its splendid attractions, the city palace is surpassed in interest by the country estate, by so much will the scope be broadened because

of larger facilities for carrying on the experiments.

For those who have large country places and who have ample hothouse facilities, Mr. Burbank recommends, for example, for beginning work under glass, begonias, cinerarias and primroses, though there are very many others which may be used. These will, however, give an opportunity for initial practice in breeding and selection likely to bring out satisfactory results. Here, too, he would pick out one plant and stick to it, following it for a number of years if needs be. As the work progresses, one's own judgment will be the better guide as to just how soon to begin work on another flower, though the one first chosen should constitute the major study.

Many opportunities are presented, too, for vegetable-breeding. In passing, it should be borne in mind by those who have a desire to combine thrift with pleasure, that no inconsiderable increase in income to a man or woman of moderate means may come from the creation of new and improved forms of floral and vegetable life. In order, of course, to prepare a new flower or a new vegetable for

the market, time enough must be allowed thoroughly to test it so that it will not revert to some former inferior stage. In general, Mr. Burbank says that six or eight generations of persistence in a given trait usually are sufficient to fix that trait, and to warrant one in announcing a new flower and offering it for sale from one's own gardens or to some of the great seedsmen or florists.

Among the vegetables, potatoes and tomatoes are both very easy to work upon, and excellent results may be looked for, both in the improvement of size, flavor and hardiness. Corn of all varieties, though particularly the sweet corns, he recommends. Squashes are more difficult to cross satisfactorily, as well as melons, though they are apt to bring very satisfactory results. Considerable difficulty will be experienced by the beginner in working on peas and beans, but, if the work is successfully done, remarkable results are likely to follow. He does not think it worth while to try to improve such vegetables as cauliflower, lettuce and cabbages by crossing, because they are most excellent as they are, and to cross them might easily result in so breaking up their old

life habits and forming new ones as to result in vastly more harm than good.

This he constantly guards against in his own work,—his aim is always to make things better than they ever were before. He does, however, heartily encourage selection, choosing the best plant of a given vegetable and, from year to year, choosing the best of its plants in turn, thereby steadily carrying it upward. He suggests here, as in the case of the flowers, that one choose some one particular vegetable which he thinks should be improved—one that needs to be larger, or better-looking, or thriftier, or finer in quality, and work on and on with it, as with the flowers, until the end desired is reached.

Mr. Burbank urges the work of plant-breeding upon clerks, upon laboring men, business men, professional men, especially girls and women,—upon any man or woman who would like to take a hand in making the earth a more beautiful place in which to live.

He points out the fact that results of surpassing importance may come to the hand of any man who takes up this work primarily as a pastime or as a means of health. No man can

tell how a given experiment may end. Sometimes, even in his own work, carried on upon so vast a scale and with apparently a command of every possible avenue of knowledge leading up to a given test, a plant will now and then burst forth in some new and wholly unexpected direction and accomplish marvelous results. It is much as though the spirit of the plant had been waiting in embryo all these years for some one to bring it forth to life.

He lays special stress, too, upon the fascination of the work. Here is a man who has been engaged in plant-breeding for nearly forty years, who has created more new forms of plant life than any other man who has ever lived, who has been what one might almost call surfeited by successes, but who takes up each new experiment with as great a zest as ever, whose eye sparkles and whose face glows over a new development or the solution of a problem as vividly as it did when he began the work many years ago. For a man who is accustomed to the cold hard facts of the every-day, dealing with problems whose chief factors are dollars and cents, —for such a man to be able to take a life and train it into new

The "Burbank" and "Tarrytown" cannas under test at Santa Rosa, where they originated

ways, to change its habits, to break up old traits, to make it more beautiful and more useful,—in a word, to handle and mold it as the potter his clay,—all this has in it a fascination beyond the conception of one who has never entered upon such a course.

Again he makes this point: That plant-breeding for the amateur is one of the most important aids to health. Plant-breeding and selection can never be carried on at their best save in the open. To be sure, there are tests which may be begun, and some which may largely be carried on, in the winter months indoors, and these have their own peculiar interest, but there is a large part of the year in any temperate climate, and almost the entire year in some portions of the country, where the work of plant-breeding can be carried on out-of-doors. It is in this outdoor life that Mr. Burbank sees one of the greatest goods that can possibly come to a man compelled for a great portion of his time to an indoor life. The plant-breeder, he maintains, should have neither time nor inclination to be sick.

Highest of all his reasons for urging plant-

breeding upon all people is its distinct moral influence.

No man, he holds, can be a successful plant-breeder and practice deceit. He stands face to face with Nature, who never lies. No man, as he puts it, can come close to the heart of Nature and see how absolute is her honesty, never for a moment deviating a hair's breadth from the line of truth, and not be made a more honest man for the contact. In short, beyond all spirit of ethics, a man, he puts it, must be an honest man or he will never succeed at plant-breeding;—if he is not an honest man when he begins, Nature will make him so or drive him out of it.

So there are five cardinal points in Mr. Burbank's argument for the extension of plant-breeding among people of all classes:

1. The possibilities in the creation of new flowers and vegetables of surpassing value.

2. The intense fascination of the work, not only giving delight but broadening and deepening any life which takes it up.

3. The opportunity for the production of flowers and vegetables which shall have a distinct commercial value.

4. Its hygienic bearing upon those who wish to maintain the good health they already have and upon those who are seeking the health they may sadly need.

5. The absolute necessity for devotion to truth—the breeding of honesty.

I saw one day on a piece of paper which a friend had pinned to the wall in Mr. Burbank's little sitting-room this quotation from his favorite author, Emerson, singularly appropriate to such a man, but which any man who makes a new flower may some day be able to take to himself:

"If a man write a better book, preach a better sermon or make a better mouse-trap than his neighbor, though he build his home in the wilderness, the world will make a beaten path to his door."

CHAPTER XV

HOW MAY I DO IT, TOO;—GRAFTING

HE who is fortunate enough to stand some midsummer day on the summit of the Macayamas, an inner spur of the great Coast range, hard by the Pacific and skirting the beautiful Sonoma valley, will look out upon a scene of surpassing interest. In the foreground lies the fertile valley, with the fruit of its hundreds of ranches ripening in the mellow sunshine, pears and peaches, apricots and apples, plums and prunes and cherries, with here and there great vineyards heavy with grapes, the whole broken in upon by wide green fields of hops and broader stretches of yellow wheat, with the reapers already at their work. Through the valley flows the winding Russian river, emptying at last through a pass in the mountains into the Pacific at the point where the Russians came down in the early days and sought to fix their flag upon Spanish soil; while far through the distance, across the

green and yellow valley, rise the white peaks of the high Sierras two hundred miles away, their summits forever clothed in snow, keeping watch above their lower mountain wards and over the fair valley below. Just across the valley over the roof-tops of Santa Rosa you may see the low hills of Sebastopol ;— there lie the acres which have given scope for the great work of Mr. Burbank. Here is the culmination of the tests, the great proving grounds where the final standard is set up, alongside of which the flower or fruit must measure itself or be doomed to death.

On these grounds, reaching eighteen acres in extent, the grafting of trees and the raising of seedlings goes on from year to year, as well as very much extensive work in pollenating and selection. And the scale on which these things are carried forward is larger than any ever before known in the history of the world.

A sunny, beautiful spot it is, far from city sounds and strifes, lying softly asleep in the golden sunshine with the fair hills beyond, purple or crimson or yellow or white as the summer flowers come on in never-ending procession. Asleep it is, and yet awake,

insistently, aggressively awake, for here from dawn to dark a life of the most tense activity is lived where things must be done with the regularity of a machine and the persistence of the sun in its course. Here the field experiments are carried on, and here Mr. Burbank does his largest work. Flowers are raised here by the hundred thousand, by the half million indeed, waiting the eye of the master of them all who shall say what one out of all their vast number shall be saved. Here seeds of all manner of fruits are planted by the hundreds of thousands if needs be, apples, pears, peaches, quinces, nectarines, plums, prunes,— a list as long as the list of the world's best known fruits. Here are long rows of young trees, hardly saplings in size, from two to five years old and from three to five feet in height, standing in serried rows so close to one another that the tiny branches intertwine. They will all be scrutinized one of these days, and the best of them all, one perhaps out of a hundred thousand, will be saved. The rest will be dug up and burned in great brush heaps. Sometimes there have been as many as fourteen of these huge heaps, comprising from

sixty to seventy thousand shrubs or young trees in a single test burned up in a single day, and simply because they did not come up to the standard set for them.

Here and there after such a slaughter you may see a tiny little tree, perhaps leafless and certainly to the eye of the layman presenting no signs of superiority. But it bears a curious little badge, a white streamer of cloth tied about its middle, the sign that henceforth it is sacred,—it is the one best one of the thousands.

Some idea of the magnitude of the work may be obtained from the following figures, illustrating the average number of fruits under test at a given time at Sebastopol from year to year:

Three hundred thousand distinct varieties of plums, different in foliage, in form of fruit, in shipping, keeping and canning qualities, sixty thousand peaches and nectarines, five to six thousand almonds, two thousand cherries, two thousand pears, one thousand grapes, three thousand apples, one thousand two hundred quinces, five thousand walnuts, five thousand chestnuts, five to six thousand berries

of various kinds, with many thousands of other fruits, flowers and vegetables.

The grafting done at Sebastopol, like all the work carried on there, is on a large scale. In a single grafting season, which comprises about ninety working days, more than a hundred thousand grafts will be set, covering a wide variety of experiments going forward at the same time with many different kinds of fruits. From these grafts will grow in a single season material for nearly ten million additional grafts. Some years since, a company was formed in California whose entire business was the making of grafts from one of Mr. Burbank's choicest plums, selling the grafts to nurserymen and fruit-growers all over the world.

At various points throughout the grafting section of the grounds young men may be seen perched on the tops of ladders in the midst of the branches of the trees upon which the grafts are set. In this, as in the case of flowers and vegetables, Mr. Burbank stands ready with suggestions for those who wish to take up this branch of the work.

From the young trees which have been

Showing method of grafting

saved out of the burnings in the different tests branches are cut away, and each branch, little more than a twig in size, not more than half as thick as the little finger, is cut up into pieces about two inches long, each piece, technically called a cion, bearing two to three buds. The tops and side branches of the tree which is to serve as the host for all the many grafts must be cut away, leaving the tree presenting a peculiarly grotesque appearance. In the end of each branch the pieces of the twigs from the little trees under test are to be placed. These host, or parent, trees are used from year to year, sometimes a single tree bearing five hundred distinct kinds of grafts at the same time.

The workman who is grafting is equipped with a sharp pruning-knife, a saw to cut away the upper branches, a pot of melted wax, a brush and some pieces of white cloth. In the end of the sawed-off branch of the parent tree he cuts a slit with his knife. He has made one end of the two tiny grafts he holds wedge-shaped. One of the grafts he holds in his mouth, while he forces the wedge of the other down into the slit. Then the second graft is

stuck in place, sometimes three or even four to a single branch, the pot of melted wax is lifted up, the branch end and the graft are thickly spread with it, a white cloth is wound about the joint—the union is complete; and rapidly the sap of the old tree begins sending its life-forces up through the new life growing upon it. The graft grows on and on until it is two or possibly three seasons old; then it puts out its own buds and flowers, bears its own fruit, wholly different it may be from any other fruit growing upon the other branches.

The union of the graft and the parent tree will not be complete unless the cambium of the two is merged. This cambium is a layer of viscid, mucilaginous substance composed of cells, lying between the bark and the wood of the tree and from which both derive their growth. Mr. Burbank calls it a predigested food, for the nourishment of the new graft.

Sometimes the workman makes a long slanting cut instead of cutting the branch off square and makes a similar cut in the graft. Two slits are then made in each, and the tongues of the graft thus formed are forced down into the slits of the branch.

Many other kinds of grafts are in use by horticulturists, but Mr. Burbank considers these two quite sufficient. Budding, which is the placing of the bud of the graft or cion underneath the bark of the parent or host tree, he very seldom uses.

Some years since, a profound discussion was carried on in England over grafting, the opponents of it claiming that it was always a makeshift, often a fraud; that it was, in effect, only a kind of adulteration; that any fruit tree that would not succeed on its own roots should go to the rubbish heap; that grafted trees are coddled, while own-rooted trees are in all ways infinitely better, healthier and longer-lived. It seems quite enough to say in this connection that the man who has carried on the blending of tree and cion upon a scale of greater extent than any other man finds grafting not only eminently successful but imperative. One single series of experiments carried on for so many years and on so vast a scale as Mr. Burbank's experiments is sufficient to disprove many theories and to overturn many conclusions.

But there remains something else of still

greater importance,—the fruit of this graft must be superior to all fruits of its kind which have preceded it, more nutritious, more delicious to the taste, more attractive to the eye, safer to ship than any of its forbears. All these points must be settled, together with other important points as to hardiness and yielding qualities, and adaptability to various soils and climates before the new fruit can be given to the world. The demands constantly made upon him in the production of a new fruit are very many and of great insistence before the fruit or flower has been brought up to his ideal.

Some strange things happen in the midst of this grafting, and some of these, or others quite as curious, may happen to any one who takes up this peculiarly fascinating branch of plant-breeding. Sometimes in Mr. Burbank's experience the graft will influence the tree upon which it is grafted, increasing its foliage, strengthening its roots, and otherwise making it more thrifty. He grafted a Japanese pear, for example, upon a Bartlett pear, and while the graft went forward, producing the Japanese pear fruit, the parent pear tree bearing its

customary Bartlett pears, the parent tree soon took on a greatly increased vigor. Sometimes the union of the graft and the tree will be complete, but, as he puts it, in the great stress of unusual drought or fruiting the grafted portion will separate again, later, and entirely fall off. Curious results are seen in some crosses, as, for example, some plum-almond crosses where there was every possible variation in the flowers,—some of them having all stamens and no pistils, some having many petals, some having no petals, some never opening like normal flowers at all, some having no stamens but only pistils. Sometimes a cross of a peach and an almond will produce a tree as large as ten peach trees or almond trees of the same age. Sometimes the precise opposite will be the case. Now and then the graft grows up thriftily and bears fruit, and its seeds are planted with the result that none will grow. Mr. Burbank says that a certain character, or characteristic, may lie latent through many generations, or even centuries, and then appear just when the right cross is made to bring it out.

But probably the most mysterious thing that has ever happened, in some ways at least,

in all his grafting tests was that of a union of two plums, one brought over from France, there being no other plum like it in the new world, the other the Kelsey plum, well known in western America. The graft was attached to the parent tree, the Kelsey, in the usual way, but, when blooming time came, the graft, though growing heartily, put forth no blossoms. It did, however, a still stranger thing than this, one of the strangest in all plant history,—it changed the entire life of the parent,—a thing hinted at by Darwin as being in the list of possibilities but never known before. The tree, by some strange influence born of the grafting, completely changed its own life, or, at least, so changed it that its own seeds in turn developed the French plum. It thus formed in the tree itself a cross between two trees that had never been crossed before, the life of the one entering into and transforming the life of the other.

Mr. Burbank heartily recommends the work of grafting from seedlings to all amateurs, whether their grounds are small or large. He says that such immediate results need not be looked for as in the breeding of flowers, be-

cause the chances for unusually fine fruits from a given number of seedlings are not great. Very many seeds of apples, for example, may be planted, hundreds, even thousands, of them, and not one of the trees which grow from the seeds may bear a fruit any better than the apples which have gone before, while a very large proportion of them are more than likely to be inferior or worthless. Still, he holds that the chances of producing one good new apple are quite sufficient, considering the bearing of such a new fruit upon the commerce of the world, to well warrant one in carrying on the experiments. He recommends for the amateur all the hardier cherries, peaches, apples, pears and plums to choose from for beginning, and also all manner of berries. The seeds or pits from the best fruit obtainable should be kept very slightly moist through the winter for the spring planting. The larger the number of them, the greater the opportunities for interesting results. The seeds should be planted in a trench from a half-inch to an inch deep, though no hard and fast rule may be set down applicable to all. It will be necessary to bear in mind the climate in which one lives in se-

lecting a fruit upon which to work. Experiments may, however, develop some quite interesting results if the effort is made to produce a fruit which will be hardier than any grown in one's locality, thus adding, if successful, a new feature of value.

By the end of the first season the young trees should be large enough for grafting wood. The work of grafting should begin when the spring is first coming or just before the buds are swelling. The tiny branches of the young tree to be grafted should be cut up into pieces about two inches long, with two or three buds on each, and then grafted in the manner noted above.

In grafting, care must be taken that seed fruits be grafted upon trees bearing seed fruits, pit fruit upon pit fruits. For example, it will not do to graft a plum upon an apple tree, but upon another plum tree or upon an apricot, almond or peach; an apple graft upon an apple tree, and so on.

As indicated in Mr. Burbank's own work, the larger the number of seeds sown the greater the chances of success. Here, as in the case of flowers, Mr. Burbank points out the

Upper part of a tree bearing many grafts. As many as five hundred fruits are grown upon a single tree at once, no two exactly alike

possibilities of producing something of surpassing value to the world. Even in case the new fruit created is not better than old fruits of the same class, there is great satisfaction, as with the flowers, in being able to present to a friend a fruit which one has himself made; while there is before one the other possibility of producing a fruit which is to revolutionize, as many of his fruits are revolutionizing, the production of the world.

The seedlings could be transplanted from their trench and allowed to grow to maturity upon their own roots, but this would, as a rule, take all the way from six to twenty years, while by grafting them upon a mature tree they may be hurried forward to fruitage in two to four seasons. It would have been impossible for Mr. Burbank to have reached the results he has achieved if he had depended upon first raising his seedlings to the period of bearing fruit before determining their value. He could not have accomplished the ends he has reached in a thousand years.

In the way of instruments Mr. Burbank recommends to the amateur any good pruning-knife of fine steel, a smaller knife like

a budding-knife, a small can for the wax, with a paint brush to put it on the graft-joint, a stock of small strips of white cloth. Other and more elaborate grafting devices can be bought, but Mr. Burbank considers these sufficient, too elaborate an outfit being a hindrance rather than a help.

The wax he recommends should be made of four pounds of resin to one pound of beeswax, with enough linseed oil to make it work well. This, when melted up together and allowed to cool, forms a cake from which enough can be broken at any time for the work in hand, and the rest will keep indefinitely. The piece which is broken off should be heated until it is warm enough to flow easily. It should not be too soft or it will run in the warm sun, nor too hard or it will crack. The object is to protect the union of the graft and the tree by means of the wax and the enclosing bandage of cloth, and a very little experience will show when the wax is of just the right consistency. It is well, if there is considerable grafting to be done, to keep the can or pot containing the wax over a lamp or small oil-stove in order to hold it at the proper con-

sistency. A little more linseed oil may at any time be added, if the wax gets too hard. This may be regulated, of course, at will. Mr. Burbank says the wax must be a good deal harder than ordinary chewing gum.

When one has an estate of some considerable size and wishes to carry on the work of growing new kinds of fruit on a larger scale, results may be easily attained far-reaching in their extent and with still larger opportunities for the production of a fruit of unique character. To show somewhat the possibilities of reproduction of grafts, Mr. Burbank says that a single tree two years old, when cut up into grafts, will produce in that same season from three to four thousand buds. If each one of the buds from these four thousand would produce its full quota, so that it would be possible to keep up the progression, at the end of the third season the single bud would have become parent to over two hundred and fifty billions of trees.

Very little pollenating of the flowers of the fruit trees is now done by Mr. Burbank because he has made so very many combinations and has such a vast number of different

kinds of trees already started on their way that it would not be worth while to make further crossings.

In this connection it is of peculiar interest to note that Mr. Burbank has come to the conclusion, after many years of crossing, or hybridizing, and grafting, that hybridization in one sense is only a mode of grafting, both being a more or less permanent combination.

In an elaborate chart he traces side by side the parallelism of results he has noted in both grafting and pollenating:

Where, for example, the pollen of one plant acts as a poison upon another, the grafts blight and die as if poisoned.

Where, in pollenating, the union is partial, mosaic or temporary, seed is rarely produced, seedlings generally inheriting tendencies and qualities of one parent only, the second or later generations reverting fully; the grafting shows often a temporary union but not in normal condition.

Where the union by crossing is free, seedlings showing an unbalanced condition, varying widely, the best condition for scientific or natural selection, while the grafting

shows a ready union of cion and tree but separation follows under unusual stress, drought, overbearing, lack of nourishment, and so on.

In another stage of usual variation where, in crossing, the union is free, the seed of superior germinating quality and produced abundantly, the seedlings being normal with ordinary amount of variability, the grafts unite readily, thriving well; sometimes better than when grafted on their own stock.

He says on this point:

"Where the plants are very different, having a different line of descent and consequently different structure, there will be no hybridization at all. From this we have every gradation to a point where the individuals are very closely alike, and here we also have scarcely any variation at all in the progeny, a condition which favors extinction. Again, in grafting, we have every intergradation between total inability to unite and absolutely perfect blend."

Along with all the work of grafting goes constant selection, the constant choosing of the best from the best. It might be somewhat

difficult for an amateur breeder to make selection from a lot of seedlings as Mr. Burbank does, choosing the very best from a hundred thousand with unerring eye, in a single day's time, but it will require but comparatively little training for any one who is deeply interested in the work to make intelligent choice between the few young trees of beginning experiments as they come, selecting those which are in all ways thriftier and "likelier" trees. When all is said and done, selection in plant-breeding is very largely a matter of individual judgment, backed up by the largest possible knowledge attainable as to the life history and past environment of the plant itself.

Mr. Burbank offers the following suggestions as to orchard-grafting:

"Commence in January, if much is to be done. February is probably the best month on most of the Pacific coast. March is as good if the grafting-wood has been well kept. April is not too late, and May sometimes and for some things, is a good month. One and a half to two and a half inches in diameter is the best grafting size of branch for old trees.

If cut back to where the branches are thicker the tree receives too great a shock, the grafts do not take hold as well and the tree forms a close, bunchy head which is not ornamental or profitable. Graft the branches where you wish them to grow to form a new top, leave many twigs and smaller and unimportant branches to keep the sap up until the grafts have one season's growth. All suckers near the grafts should be pulled off as soon as they appear. It is very important, after grafting, to watch and cut back a part of the new growth early in the season, else the wind may get too great a leverage and break out the grafts before fully healed over. It is also often best to reinforce them for a while with a small twig or stick tightly tied to the old branch and lightly tied to the new growth."

CHAPTER XVI

COMMERCIAL ASPECTS OF THE WORK

IN forming any just estimate of the commercial importance of Mr. Burbank's work, different factors must be taken into consideration. Though it is a quarter of a century since he began the actual work of plant-breeding on a large scale, it is only within the past ten or twelve years that the most important lines have been developed. At the time he closed out his nursery business in 1893 he entered upon a series of important experiments, many of which are but just coming into fruition. It takes all the way from ten to fifteen years, in some cases much longer, to carry a new plant forward to its perfected stage. For example, the amaryllis took nineteen years, the hybrid lilies over twenty, and both are still to have further attention. Not only must the actual excellence of a new fruit, for example, be determined and its standing ascertained alongside of other fruits then in

The essentials for amateur grafting

existence, but time enough must elapse for it to become thoroughly fixed in its new ways so that it will not revert to some former condition of inefficiency.

Then, too, when all this has been accomplished, it still must stand the test of the orchard, the shipper, the dealer and the consumer. It must be grown, too, by the average fruit-grower under average conditions. As has elsewhere been noted, Mr. Burbank fits the new fruit, in so far as he possibly can, for just these average conditions, so that when it goes out from under his care he is willing to trust it to the world. But no human being can tell what the commercial outcome of a new fruit will be. It may have undoubted superiority over others of its class, but it may not at once catch the popular fancy. It may fall into the hands of some one who for one and another reason does not care to push it forward; possibly not until some other favorite has run its course. Then, again, a new fruit may require a special and particular handling in its shipment or in some other feature of its life, and unless the conditions are carefully complied with the best results will not come.

Sometimes, as Mr. Burbank puts it, the fruit-raiser must be adapted to the fruit. It must be borne in mind also, in any consideration of the commercial feature, that many of the creations of Mr. Burbank are not commercially identified with his name, having been bought by florists or horticulturists who exploit them in their own way and under names of their own selection.

Aside from all this, the very heart and spirit of Mr. Burbank's method are directly opposed to any monopolistic control of his new fruits. To get these fruits to the general public at the earliest moment possible and at the lowest figure is his highest aim. "Absolutely no restrictions," that is the key-note. One of the largest fruit-growers in California estimates that Mr. Burbank could easily be making a net revenue of two hundred thousand dollars per year if he should hold back his fruits and flowers and handle them solely for the money that could be made from them. But to do this would be to stultify himself; his measure of success has not been the standard of the dollar: success to him means the accomplishment of the greatest possible

good for the greatest possible number of people.

A number of prominent fruit-growers with a keen eye to thrift approached Mr. Burbank one day with a proposition to form a corporation or syndicate for the handling of one of his new plums, a particularly valuable one, in some ways the most important plum he had made. In a most captivating way the promoters of the scheme presented its attractions. The gentlemen interested had seen the vast possibilities in the absolute control of the fruit, and Mr. Burbank's share in the profits to accrue was alluringly presented. The project was in no way dishonorable and it was distinctly business-like, but it was in direct opposition to Mr. Burbank's life policy — to place no restrictions upon his productions but to get them running in the channels of the public at the earliest date possible. So the plum syndicate was never formed.

When Mr. Burbank began placing his new creations on the market, after he had given up the nursery business, he stated in one of his lists:

"The time, the care and the expense of

producing these new fruits and flowers are simply astounding to those not familiar with the facts. They are usually offered once only, all the main financial profit being secured by the early purchasers and planters. If in the past I had received only one cent for each ten thousand dollars added to the wealth of the world by my plant productions, those mentioned in the list could be passed out freely to all who ask; but no great undertaking can long exist without some provision for running expenses, therefore the prices accompanying this list. I have no government aid, no college endowment, and nothing whatever to keep up the work except the occasional sale of these new fruits and flowers."

One of the most prominent men in the fruit-growing industry in California, a hard-headed, successful business man who had for many years been interested in Mr. Burbank's lifework, said concerning the financial side of his work:

"Not many know of the influence that has been brought to bear upon Mr. Burbank to make a big business enterprise of his novelties.

Many have begged the opportunity of going into partnership with him on a very large scale, offering to provide all the money necessary. Eager requests for the plants that he has to sell come from every country, and he had the making at Santa Rosa of the greatest and most profitable nursery business in the world. Mr. Burbank, however, is not out for money. Money to him is only a means to an end — the blessing of mankind by as wide a distribution as possible of flowers more beautiful and fruits of higher grade than ever before existed.

"When Mr. Burbank introduced his wonderful sugar prune four years ago, I secured a hundred feet of grafting wood from him, and produced four thousand nursery trees in a single year. In the succeeding year I had over fifty thousand trees for sale — by far the largest stock of that variety then in existence. I had difficulty in disposing of the trees, because they were not then known to be a commercial success, and California growers would not plant out large quantities until they knew the public would buy the fruit. Mr. Burbank, as I knew, had sold out his

stock the first season, and I offered to furnish the trees to fill his orders. Mr. Burbank, however, replied that he had left the nursery business some time ago, and was now dropping the tree business, as he had not a moment to spare to attend to such things, but it would give him the greatest pleasure to turn over any customers he might have to me. Subsequently many different people bought sugar prune trees of me who had been recommended to me by Mr. Burbank. This incident made a great impression on me, because I knew that Mr. Burbank could make good use of the money. Is it not inspiring to know that a scientist of Mr. Burbank's fame is so free from the frailties that are induced by a love of money? Luther Burbank is a man who could be rich, but he will not consider the object as worth attaining. He is wholly devoted to making the world more beautiful with flowers, and more pleasant with new and wonderful fruits."

While many thousands of dollars have been invested in the production of the new plums, and while they have but barely begun their commercial course both here and in

foreign countries, they are distinctly threatened by Mr. Burbank himself, and this is why it is so very difficult to give any adequate estimate of the commercial value of his new plums and prunes. They are threatened because when his new pitless plum and the pitless prune which will follow are once upon the market, the death-knell of present-day plums and prunes of their class will have been sounded. These new plums and prunes promise to be just as beautiful, just as rich, or richer, just as hardy and prolific, and the place of the pits of former centuries is to be occupied with the meat of the fruit itself. As soon as this is done, many plum and prune orchards in the world will be practically supplanted, and all of them must eventually be made over to suit the new order of things.

Day by day, as his splendid plums and prunes make their way among the fruit-growers, they are paying handsomely on the investment, and they will yield their revenues up to the very limit of the date of the appearing of the new plum, and even on beyond, while it is coming into bearing, so that there will be no great and wholesale disaster. But the

hand-writing is on the wall, and fruit-growers have long since taken note of it: the revolution will be bloodless, but it promises to be complete.

I was much interested in the statement of a fruit-grower who had handled one of Mr. Burbank's prunes. It was a venture with him, for though nearly one-third richer in sugar than the French prune, much larger, and more prolific, it had not turned out the season before so well as he had hoped; though he noted, however, that this may have been in some measure due to the season itself. The important feature, however, from a commercial point of view was this, that he had simply changed the prune into a plum, selling it by the thousands of cases in the East where, on the New York, Boston and Chicago markets it sold at the head of the list on such days as it was offered for sale. The French prune with which it was competing as a prune had no merit whatever as an eating and shipping plum.

While the next few years promise still greater returns to the world from Mr. Burbank's creations, because at the date of the

The sugar prune,—larger, sweeter, earlier and more productive than the older prunes

issuance of this volume so many of them are but just coming into commercial sway, it is to the somewhat more distant future unquestionably that the greatest commercial triumphs are to be won for the world. And this is not because the present-time creations are not splendidly fulfilling their mission, but because the newer work has vastly greater possibilities. In the pitless plums and prunes, the new grasses, the thornless cactus, the new fast-growing forest trees, the frost-resisting trees, the work in new varieties of pears, apples, quinces, peaches, apricots and berries, together with other experiments under way which have not yet reached so advanced a stage, lie vaster commercial possibilities than in anything he has yet achieved, as well as a greater measure of service to the race.

CHAPTER XVII

THE CARNEGIE INSTITUTION GRANT

AS has been indicated in a former chapter, a day came in Mr. Burbank's career when it was evident that, no matter how much he still might accomplish for the world, he could not hope to go forward at a pace commensurate with his genius and his opportunities without outside aid. By aid would be meant not some subvention from some institution or state or government which would first recognize him as in want and then lend a helping hand, while establishing, at the same time, an essentially selfish hold upon him. While it was true that year by year he was running behind in his expenses, he had long since passed the period of privation, though he had never passed the point of strictest economy in order that no cent might be wasted but all devoted to his lifework. Any aid which should come to him, then, must be first of all sympathetic—using the word in its

very broadest meaning; and, next, it must be aid devoted, as he is devoted, to the welfare of the world, which should enable him to attain in his own way a still larger measure of usefulness than he could have accomplished alone. Important as his work has already been, even more must have been accomplished had there been greater freedom of service.

During a period of fifteen or eighteen years there had been frequent suggestions made by those who knew the work best that aid of some kind should be given in order that the work should not suffer. Suggestions, now and then came in reviews in local newspapers of the wonderful things being accomplished. Now and then some government official, interested in the scientific and practical departments of the broad subject of plant development, visited Mr. Burbank, was amazed at the enterprise under way, and was full of regret that the government could not take hold of the work and help carry it forward,—it would be impossible, was the usual line of thought, for the government to offer any specific aid without incurring the charge of paternalism and opening the way to an indefinite and

unfortunate extension of aid to others less deserving.

While no one else save himself could possibly know how much aid would have meant to him at times when, driven to the very limit of physical and mental strain, he could see no possible way over the financial obstacles that confronted him, yet never in the course of his life had he ever asked for aid from individual, corporate body, state or nation. Time and again foreign scientists or horticulturists visiting Mr. Burbank expressed amazement that no subvention had ever been made by his government, because the vast importance of the work was not less significant than the wealth which must accrue to the state by provision of funds to carry the work forward on larger lines.

At last the whole subject was brought to the attention of the trustees of the Carnegie Institution at Washington. After a searching consideration of the matter, an offer was made of a subvention, or grant, it is understood of one hundred thousand dollars, ten thousand dollars per year for ten years. Briefly stated, the object of this Institution, founded by

The re-created wild onion flower, *Brodiæa capitata*, changed from a deep purple to purest white and greatly increased in size

Andrew Carnegie and incorporated in 1902, is as follows:

"To promote original research as one of the most important of all subjects; to discover the exceptional man and enable him to make the work for which he seems specially designed his lifework; to publish and distribute the results of scientific investigation; to increase facilities for higher education. In the field of research the function of the Institution is organization; —to substitute organized for unorganized effort; to unite scattered individuals working independently, where it appears that such combination of effort will produce the best results; and to endeavor to prevent needless duplication of work. The Institution does not attempt to do anything that is being well done by other agencies; to do that which can be better done by other agencies; to give aid to individuals or other organizations in order to relieve them of financial responsibilities which they are not able to carry; to enter into agreement with any organization for the purpose of conductive research unless the conditions are such as to reasonably assure continuation of the agreement through a sufficient period of

time to complete the special research entered upon."

It will thus appear that the Institution comes into particularly close consonance with the work which Mr. Burbank had so long been carrying on under peculiar difficulties.

The grant became available at the beginning of 1905.

There are two important features, or phases, of Mr. Burbank's work of which the Carnegie Institution takes special cognizance. One of these is its practical bearing upon the welfare of mankind. In a work so many-sided as this, the scope of this practical application is at once suggested,—how best to effect this practical application is of paramount importance.

Many times in his career Mr. Burbank has been forced to abandon a given experiment, not because it did not promise to yield admirable results, but because he did not have sufficient funds to carry it forward. This was particularly true of those tests which he would have been glad to follow out because of the especial scientific interest that attached to their development. The actual expense

for manual labor for the carrying forward of a single test through a long series of years is large in the aggregate, especially so since the manual labor for his service must be backed up by keen intelligence and sound judgment, a combination not always easy to be obtained. There have been very many tests, hundreds sometimes, under way at the same time, and it was inevitable that some must fall by the way. So great has been the demand for funds for the maintenance of major tests that many of the minor ones, which might easily have been advanced to the higher position, have, like a neglected plant, died for want of support.

It is of special interest in this connection that Mr. Burbank's work has been cumulative from the very inception. With each new triumph the way has opened to others, so that at no time in his life had there been so many great opportunities before him as when this grant was proposed. Best of all, as the years had come and gone, he entered upon each new experiment fuller of interest in the outcome, deeper in his zest over the developments. Couple with this maturity of

all his powers,—judgment, discrimination, intuition, observation, scientific thought in its widest and deepest bearing, and the like,—and you have the ideal conditions for enterprise of the loftiest type.

But in order that these larger results might be reached, larger revenues must be available to draw upon. It is this revenue that the Carnegie Institution has so wisely provided. The grants of the Institution are never charitable. It has no funds for indigents. It is intensely practical in its methods and in its administration of its funds. It places no money save where, directly or indirectly, its expenditure will bring an ultimate practical or scientific benefit. Doubtless much time might be saved to applicants for aid if this were more carefully considered.

The practical side of the work will go forward under the grant precisely as it has gone on before during all the years of Mr. Burbank's great work, save that its scope will be much broadened. Tests once impossible will now become possible. With a larger force of men trained in his methods he will, as the years pass, be able more and more to

On the proving grounds at Sebastopol. Pampas grass in the center, various bulbous plants in the foreground

delegate work which once he was unable to delegate, thus not only saving his own strength for the new and more important tests and for the general oversight of the work, but permitting a much larger number of experiments, if necessary, to be under progress at the same time, and vastly to accelerate the movement of the work. This is not a department of the work which calls for more elaborate apparatus,—the earth and man, these are the essentials, and the higher the intellectual strength and sympathy of the men Mr. Burbank is able to secure, the larger the results. The object is not to attempt in any way to curb or direct or interfere: this would be absolutely fatal; what is intended is that there shall be constant sympathetic aid.

But, at the same time, the Institution stands also for scientific attainment, and the completest measures will be taken for the keeping of adequate data, as well as provision for the making of laboratory records. To this end trained experts who are in close touch and sympathy with Mr. Burbank, will aid in the preparation of the mass of important data which must steadily accumulate in so extensive

a work. As will be shown in a succeeding chapter, Mr. Burbank has by no means been lacking in the matter of general scientific record, but the new arrangements will give opportunity for the registering of much that should be preserved for the benefit of others. Microscopic and photo-microscopic work, as well as elaborate recording of the details in the life history of plants under test, will be followed with the utmost care. Funds will be provided for this and for the necessary attendant expense in equipment and salaries. It was utterly out of the question for Mr. Burbank to prepare such elaborate data as will now be of record, greatly as he desired it, though it will appear in the description of his novel plan books that he has never for a moment lost sight of the absolute necessity of fundamental records.

As the work progresses through the years, there will be publication of the data compiled and set in order by trained men. Elaborate photographic records, aside from micro-photographic ones, will give charm as well as definiteness in preserving the larger events in the life history of fruits and flowers. The only

man who can ever succeed in the deep sense in association with Mr. Burbank in the development of the scientific phases of his work is a man who has not only the liberal training of the schools and the inborn love for research, but who sees beyond the mere matter of academic record, important though it be, into the noble field of true science where he who wins for science and the world must stand ready to divest himself of the impedimenta of precedent the very instant it be found inadequate. Such men, working with this man, should not only win new triumphs for science, but set forward the standard of the practical. It need scarcely be added that such men will be in unquestioned sympathy with Mr. Burbank and the great work which lies before and behind him.

It may be noted, in passing, as an illustration of the expenses attached to the work, that, during the busiest season, when grafting, transplanting and general culture are at their highest, between six hundred and eight hundred dollars a month must be paid out for laborers' hire alone—a sum that will increase rather than decrease as the work advances.

To one who gives even a cursory glance,—and this only at the practical side of this great work,—this grant will appear to have been splendidly bestowed. The value of it must still more clearly come into view as the years pass. It is to be doubted if the Institution ever offers a subvention for a more commanding purpose. The work is not only of supreme interest to people in every walk of life, but it is of transcendant commercial importance, as well as having a powerful bearing upon the welfare of the people. The results of this work are not for the benefit of the Carnegie Institution. They are not for Luther Burbank. They are not for his state, or his country, but for all states and all countries, and for all the centuries. And should it happen as a result of this grant that some other man, or men, shall be raised up who shall prove themselves worthy to carry on this great work when he who has inaugurated it shall lay it down, thus preserving continuity of effort, a still greater boon will have been conferred upon mankind. There is no other enterprise in the world by which this may be measured. It stands alone, unique among movements

for practical and scientific betterment. The scope of its possibilities lies out beyond the sweep of the imagination. The Carnegie Institution, in granting this subvention to Mr. Burbank, has performed a splendid and substantial service for the world.

CHAPTER XVIII

A DAY WITH MR. BURBANK

IF in this chapter some impression may be conveyed of the tremendous strain under which this great work is done, a point will have been gained. If it shall serve in any measure to check the advance of the thousands of people who annually, and in steadily increasing numbers, visit Mr. Burbank out of a natural curiosity, the full end will have been reached.

Far too often the day with Mr. Burbank begins in care, advances in anxiety, closes in exhaustion. Not the least but often the greatest cause for this lies in the visits of the thoughtless, people with the best and kindest of intentions but with lamentable lack of foresight. No man ever lived with wider and richer hospitality, with stancher friends; no man ever enjoyed intercourse with personal friends more keenly. Surely, even a man who has made a great place in the world, who in a certain

Mr. Burbank pollinating the blossoms of a plum tree

noble sense is the common property of the people, is entitled to his own privacies; even more, from the standpoint of achievement for the welfare of the world, is entitled to his precious hours of labor, when a single thoughtless interruption may be the means of irreparable loss.

Each day with Mr. Burbank is a composite, or perhaps better put, a mosaic; and no two are just alike. At certain seasons of the year, particularly should some great fertilizing test be under way, he is up with the sun, when the flowers are opening and the bees are a-wing and Nature is in her gentlest and most ingenuous mood. For hours on such a day as this he must work unremittingly, until the pollenating of great numbers of plants has been completed and Nature has been made ready to be big with wondrous secrets. Commonly, he rises about seven o'clock and breakfasts at eight. If much worn on the preceding day, he may lie in bed until nine, or possibly ten o'clock, for he is an ardent believer in the efficacy of absolute physical and mental rest following periods of prolonged toil. He has proven for himself the recuperative and

indeed, curative, value of absolute physical relaxation.

Work is always awaiting him, always, day in and day out throughout the entire year ; for he labors under a sky so genial that some gentle life of nature is stirring the whole twelvemonth long—some life in whose creation or transformation his hands are having a part. The workmen must be superintended day by day, even hour by hour, for this work is like none other—there is no pleasant smoothness and perfection of routine; for at any moment may arise a problem so urgent of solution that the whole day's toil may need alteration to suit its insistent conditions. It is a thousand to one, too, that no man may solve the problem but the master, the one whom these gentle workmen revere as few employers are ever revered. Possibly even before he has had his breakfast, he may be seen passing swiftly out of the house and making his way with rapid strides to some distant part of the grounds, where he may have seen from his window some new workman doing precisely the opposite from what he had been told to do. Many a time, in his ceaseless search for the

right men, he has taken on a workman highly recommended to him, only to discover him just in the nick of time doing something that would result in serious, perhaps irreparable, harm. Indeed, more than once such harm has been done, and the discharged man, perhaps, never knew what it was that caused his release. Possibly, if some new weather situation has arisen, the order of the day may at once be changed to meet the new conditions.

Some of the men are pulling out tiny weeds in the midst of long rows of delicate green plants no higher than a man's thumb; some are spreading some particular kind of soil over the earth where a test calling for this soil is to be begun; some are hoeing out the weeds among larger plants, some are laying out beds, or sorting bulbs in the storehouse, or transplanting delicate plants from the greenhouse to outside beds, or any one of a thousand and one other duties. Every man is working as though his life depended upon it, and every one of them feels in his heart of hearts a strong fine throb of pride that he is thought capable, by the gentle man who goes in and out among them from day

to day, to be an instrument in his hands for the furtherance of a great work.

But to come back to the breakfast which must be eaten some time, whether before, or after, or during the hours of early superintendence. It consists of simple food, a trifle old-fashioned as regards fads, but ample and wholesome and balanced. If for the moment there is nothing particularly pressing in the experimental plots, he gives an hour or two after breakfast to his more important correspondence. Time was when he attended in person to every letter that came, so absolutely conscientious was he toward this as toward every other demand of his lifework, but the day came when to do this and have any time for the thousands of other more imperative demands upon him was out of the question. So he shifts the main responsibility of correspondence upon other shoulders. And yet there still remain many letters, in the very nature of the work itself, answering of which he may not easily delegate,—letters from men of prominence in the scientific world, letters from devoted friends, communications relative to important steps in this or that creation

under way,—these he must dictate answers to direct, or make notations in his clear strong hand as to the answer to be sent. The magnitude as well as the extent of the work may often be indicated by a single day's mail. Letters arrive from all over the United States, from Mexico, from many South American points, while there is scarcely an out-of-the-way place in Europe or Asia where fruits or flowers are cultivated that has not either some collector who is in constant touch with Mr. Burbank in supplying him with rare plants and seeds for experimentation, or some florist or horticulturist anxious to have some fruit or flower from the famous gardens of Santa Rosa. One large scrap-book contains an extensive list of foreign souvenir postal-cards bearing greetings from people he has never seen or heard of before. Very many letters come from Great Britain and her dependencies, the interest in Mr. Burbank's work being particularly deep among Englishmen. France and Russia send many letters, as do Italy and Germany, while many come from India, China, Japan and Australia. There are communications, too, from crowned

heads and others high of rank. One of the most important features of Mr. Burbank's correspondence is the matter of translations from foreign languages. It is interesting to note that it has become the custom in certain parts of Mexico and South America to make inquiry in regard to an American fruit or flower offered for sale, whether or not it is a "*Burbanco.*" If it is, it is accepted without question as being what it is represented to be.

And the letters asking for aid and for situations,— their number is multitude. Long ago he was forced to adopt this form:

Santa Rosa, California,..................................189

Dear Sir: In reply to yours of.............................: The constant stream of applications from all directions for a position has necessitated this printed slip, as I do not wish to be considered thoughtless in regard to these worthy applications, not one in ten thousand of which can be complied with. I employ my neighbors only, most of whom have been with me for many years, and cannot give steady employment to most of these even, and have no possible place for any one else. It would be exceedingly pleasant to me if I could employ the army who apply. My kindest and most heartfelt wishes are that each may find the employment desired. Sincerely yours,

LUTHER BURBANK

The original Burbank plum tree. Millions of trees have been grown from it

Many letters which come make inquiries upon all manner of subjects near or remotely related to the work and suggesting calls for further consultation with Mr. Burbank in person. To such this card is sent:

> ASK NO QUESTIONS WHICH YOU THINK CAN BE ANSWERED ELSEWHERE
>
> If a reply is desired which requires more space than a postal card affords, *always enclose five dollars.*
>
> All visitors to the home place are limited to five minutes each, unless by special arrangements.
>
> *Absolutely no visitors allowed at Sebastopol farm*
>
> Everybody would be graciously welcomed, but the burden of entertaining the multitude has become so great that the experimental work has been very seriously crippled.

The number of letters to be answered every year is upwards of forty thousand. In two months of one season fifteen thousand were received.

Sometimes the midday meal is eaten at one o'clock, sometimes not until three or four in the afternoon, for if he has been compelled to lie late in the morning frequently but two meals a day are eaten.

In the afternoon it is more than likely a

second grist of correspondence will have to be attended to, while every moment not given to it must be devoted to the tests. It is not only the tests that have been under way for years that need attention in order to see that the growing plants are cared for, but new tests are constantly being started and the greatest care must be exercised in the details of the work. A single false pollenation, a single error in transplanting, a single mistake in uprooting a plant for a weed, may interrupt, even if it does not wholly destroy, a test of vast importance. And one of the most wearing of all the anxieties is found in this: That there is not an experiment, however carefully it has been planned and however closely the future results of the test have been estimated, that may not, through some untoward act of man, or insect, or bird, or element, turn out badly in the end. Then all must be done over again and again, until the end sought for is reached. Nor is there a test, so great the compensation, which may not turn out, as many of them have, far more important to the world than had been anticipated.

As soon as the afternoon correspondence is

completed, he is out again in the proving grounds, and until the sun goes down there is always something which needs attention.

But while this work fills in every moment of the day, be sure it is not all. In a single year fully six thousand people visit the grounds at Santa Rosa—as many would go to Sebastopol if they could get in. These visitors almost without exception want to see Mr. Burbank. No matter what else they want, they want to meet him. And it is natural and not culpable, but it is deplorable. They are easily divided into three classes: Those who come from curiosity, whom Mr. Burbank never sees if he can avoid it; those who come from genuine interest and who are content, when some attendant tells them Mr. Burbank cannot be seen, to look over the grounds; those who come by appointment and whom Mr. Burbank wishes personally to see. The first class is far and away larger than the other two put together and more difficult to handle. But there remains a large enough number whom Mr. Burbank feels that he must see, to consume very much of his time and to make direct inroads upon his strength. These are

seen with all possible dispatch, in order that no time may be wasted.

When the grounds are reached there is, just inside the white picket fence, a sign which reads:

> NOTHING FOR SALE
>
> ALL VISITORS CALL AT THE DOOR

When the door is reached, there is another sign which reads:

> ALL VISITORS ARE LIMITED
>
> TO FIVE MINUTES EACH UNLESS
>
> BY SPECIAL APPOINTMENT

In passing, I cannot too strongly emphasize the fact that Mr. Burbank's grounds are absolutely private. Still stronger placards than the above now appear at the entrance gates, prohibiting all visitors without previous arrangement. This has been made imperative because of the steadily increasing stream of people who have been making a Mecca of his home.

But, should a person succeed in running the gauntlet of these protective signs, there is still another provision which must be faced. When the inside of the door is reached, this slip is in readiness. I take the current one from the block on a day in May, 1905:

Visitor No. __________ *Date* __________

What is your business with Mr. Burbank? __________

For whose benefit is this interview? __________

Your name? __________

Your address? __________

Remarks __________

All visitors are limited to five minutes unless by special appointment.

Mr. Burbank's work is of such a nature that he cannot well be interrupted.

Then, in case the visitor has particular and valid reasons for visiting Sebastopol, where the larger proving grounds are located, he faces this card which was not prepared looking to a source of revenue, but in order, if possible, to keep down the number of actual applications:

TICKET OF ADMITTANCE TO BURBANK'S SEBASTOPOL EXPERIMENT FARM

(Void unless dated and signed by the Proprietor)

Date ______________________________

Signature ______________________________

Prices for Admittance of Visitors during the busy months of April, May, June, July, August and September: Each person, one hour, $10; each person, one-half hour, $5; each person, one-quarter hour, $2.50.

Admittance will be allowed at one-half the above-named prices during the other six months. When there are two or more in the same party, twenty-five per cent discount from these prices.

Note.—Everybody would be graciously welcomed to the farm, but the burden of entertaining the multitudes has become so great that the experimental work has been seriously crippled.

There is but one object in all these restrictions, to protect Mr. Burbank both as to wastage of time and physical vitality. He has set apart the month of July, during which time there are likely to be slightly fewer demands upon his care in the actual work, as his reception month, when more freedom is allowed in the way of admitting visitors to the grounds at Santa Rosa.

On certain days in the week Mr. Burbank leaves Santa Rosa about nine o'clock in the morning and drives over to Sebastopol, some

Cultivating the mammoth pieplant. Some leaves are three to four feet across. Mr. Burbank is the central figure

eight miles distant. Here he devotes the entire day to overlooking the larger work of the main proving ground. More men are employed here than at Santa Rosa, as the work is more extensive. Great difficulty is experienced in getting men who can adapt themselves to the work. The day spent at Sebastopol is particularly hard, for the work of the week preceding must all be inspected and plans laid down for the following week. Here there must be constant care exercised that no mistakes be made, for mistakes here, where the tests have so far advanced that actual results are being reached, are fatal indeed. Hundreds of thousands of fruit trees of all kinds needing inspection; work upon berries, grapes, ornamental shrubs of many kinds; extensive tests in flowers, on a scale larger than could be carried out at Santa Rosa; experiments in fast-growing trees, tests of plants which have been recommended from all parts of the world as suitable for further development or for combination with other plants,—these are some of the factors that unite to make the days spent at Sebastopol wearing to the very last degree. In so far as

possible, the work is delegated; still, very much of it cannot be given over to other hands but must be under the immediate eye of the one who has conceived the plan, who alone knows how it should be developed, who alone can tell the proper moment for action should a radical change at any time appear necessary.

When the evening comes, it is a worn and tired figure that curls up upon a low couch in his little living-room,—tired physically no less than mentally, many a time worn to the very verge of exhaustion. An hour or so he lies silently resting, not asleep, for his mind is eternally turning upon the work before him, but relaxing in so far as possible. Even now he is not left to himself; for the messenger boy may still reach him; special-delivery letters come by night as well as day; telegrams have no heart.

But by nine o'clock, if all is well, he is in bed—the day is over. Another one will not be long delayed, fuller, it may be, of care. Yet all the days in this man's life are rich in the splendid consciousness of duty done, glorified by the joy of having helped the great primal forces of Nature to help mankind.

CHAPTER XIX

HIS PERSONALITY

THERE are certain men whose lives are so open and free that the innermost pages are disclosed at a glance. Certain others need only the lightning flash of circumstance or occasion to reveal phases of their life long hidden. Certain others remain the sphinx to the end.

Luther Burbank belongs to no one of these classes, but rather to all of them. With nothing secretive in his nature, he yet has depths that his nearest friend does not fathom. Willing at all times to be himself precisely as he is, indeed, more, never playing the hypocrite by cloaking his own estimate of his own deeds, though absolutely unspoiled by praise and impregnable to flattery, he is yet constantly disclosing some new and striking characteristic. Clarity itself, and frankly unreserved when he meets those who understand, he constantly baffles understanding by the subtlety

of his thought. Some of those who have believed they knew him most completely have found, even after the course of years, that they have not yet crossed the threshold.

A slight, lithe figure, which would appear frail if it were not so well in proportion and so closely knit, a figure full of nervous strength; hair slowly whitening, with a brown mustache slightly streaked with gray; intense blue eyes that are full of fire, or a-glint with earnestness, or twinkling with merriment, or sad or gay or somber, as the mood passes; a sensitive mouth and chin; the bronze of the western sun upon his cheeks. It is the face of a poet, or a philosopher, or a sagacious man of affairs, or, in the nobler sense, a fine, true mystic; for all of these, and more, he is bound into one.

He is quick of movement, soft and gentle of speech, a rare conversationalist when in the mood, though rather inclined to draw others out than to advance his own views. Once started upon some subject of deep interest, however, and assured that his auditors are in sympathy, his words come swift at the bidding of his swifter thoughts. Sometimes in conver-

sation, if he be deeply stirred, he is impetuous in movement, emphatic in gesture, hardly able to confine himself to the bounds of moderation. And yet he never goes a hair's breadth outside the fine, strong line of truth that binds him like a thread of gold to all that is highest and noblest. When any topic is under discussion that takes root in his own life experience, he speaks with great earnestness, and if there perchance be some wrong that needs righting, he minces no words.

He is swift but genial in repartee, generous in his praise of others, instant in his words of sympathy to one in trouble. At times when he is worn with prolonged bodily and mental toil at the crux of some great test, when every faculty of his being is pushed to the utmost limit, he may rise suddenly after a long period of rest upon the low couch in his room on the entrance of a friend, and then, if the conversation but have a nimble turn, he is suddenly alive with animation, entering with zest into a story and laughing with the abandon of a boy. His wit comes out sprightly but never biting; his humor flows graciously—it is never lethargic or ponderous. As swiftly as the con-

versation shifts he is in touch with every change, discussing some deep problem of human life or dissecting a pseudo-scientific foible, or illuminating a scientific thought some other man has cloudily expressed, or cutting into some current fallacy of modern education or politics or religion, making an excision as deft as it is scientifically accurate. He is as zestful as a skilful surgeon over some remarkable case when he dissects a limb or the main trunk of theology, and he scarcely considers anesthetics necessary in such an instance; but no man is more reverent in the presence of true religion. He is never happier than in a care-free romp with a merry child, but he meets the most distinguished scientist with the gravest dignity.

In any discussion of his own work, Mr. Burbank likes best of all to have specific, definite questions asked. The answers come without hesitation and in clear, understandable language. From time to time, when he first began selling his new creations, he issued catalogues descriptive of new fruits and flowers. They were models of their kind and greatly enjoyed by people in all quarters of

Mr. Burbank's home, at Santa Rosa, California

the globe. Captivating in their style and alluring in their contents, they were never marred by overstatement of excellencies. One is constantly struck by the clarity of his conversation and the freshness and vividness of his language, and, while this has usually been the gift of all great scientific thinkers, it is especially noteworthy in this instance because of the fact that while he was well grounded in rudiments and has read widely, he has not had the exhaustive literary training of the schools.

He closed one of the very few public addresses he has ever given, in this wise; the words are characteristic:

"Who can estimate the elevating and refining influences and moral value of flowers, with all their graceful forms and bewitching shades and combinations of colors and exquisitely varied perfumes? These silent influences are unconsciously felt even by those who do not appreciate them consciously, and thus with better and still better fruits, nuts, grains and flowers will the earth be transformed, man's thoughts turned from the base, destructive forces into the nobler productive ones, which will lift him to higher planes of action toward

that happy day when man shall offer his brother man, not bullets and bayonets, but richer grains, better fruits and fairer flowers.

"These lines were penned among the heights of the Sierras, while resting on the original material from which this planet was made. Thousands of ages have passed, and it still remains unchanged. In it no fossils or any trace of past organic life are ever found, nor could any exist, for the world-creative heat was too intense. Among these dizzy heights of rock, ice-cleft, glacier-plowed and water-worn, we stand face to face with the first and latest pages of world creation, for now we see also tender and beautiful flowers adding grace of form and color to the grisly walls, and far away down the slopes stand the giant trees, oldest of all living things, embracing all of human history; but even their lives are but as a watch-tick since the stars first shone on these barren rocks, before the evolutive forces had so gloriously transfigured the face of our planet home."

At the dedication of a park which had been given to the children of a neighboring town, in the suburbs of San Francisco, in memory

of a child of the donor, Mr. Burbank made an address which I may briefly quote from as indicative not only of his devotion to children but of his ability to express a beautiful thought in graceful fashion:

"I love sunshine, the blue sky, trees, flowers, mountains, green meadows, running brooks, the ocean when its waves softly ripple along the sandy beach, or when pounding the rocky cliffs with its thunder and roar, the birds of the field, waterfalls, the rainbow, the dawn, the noonday, and the evening sunset,—but children above them all. Trees, plants, flowers, they are always educators in the right direction, they always make us happier and better, and, if well grown, they speak of loving care and respond to it as far as is in their power; but in all this world there is nothing so appreciative as children,—these sensitive, quivering creatures of sunshine, smiles, showers and tears."

I may not better illustrate one phase of this many-sided man than to say, on the testimony of a friend, that the first time he looked upon the noble sweep of the Yosemite Valley he did not go into an ecstasy of expletives, but

stood apart with his eyes filled with tears; or to note that he counts no day completed in which he has not said a cheery good-morning to his aged mother, now faring near the century line, looked after her with the utmost devotion during all its hours, and tenderly said to her good-night at the going down of the sun, even though she sees such acts but dimly through the long mists of the years.

I have talked with many townsmen of this man, those who have known him in lean seasons when struggle was constant and the current strong, in other days when the praise of the world flowed high but never to submerge him; and never a one but has been quick with the deep, strong words of praise for their townsman and neighbor,—not one but who, in quaint, crude words or more elaborate phrase, has pronounced him a man whose life stands above reproach, whose character is of the noblest type, whose heart is overflowing with that kindness that ever makes for malice toward none and charity for all. It sometimes happens that a man assigned by the world to a high position is held in scant esteem by the common people among whom he lives;

but I venture to say no man in public or private life has arisen who holds so high a place in the affection of his neighbors and fellow townsmen as this man, whom they have come to regard as the incarnation of the highest and best in human life. Whoso holds this praise too high shall but stay some days in the fair little city of Santa Rosa, a very bower of roses in a valley of beauty set in the midst of the emerald hills, and from day to day make search for one who shall be out of harmony with these words. Or whoso wishes to know how deeply he impresses those who see him but for an hour or a day, by the sincerity of his speech and the winsomeness of his welcome, let him search among the tens of thousands who have paid him call, be they high of rank or humble, and see if he may find one among them who does not say:

> "He was a man, take him for all in all,
> I shall not look upon his like again."

So insistent are the demands of his work,—for there is no time in the year when some test is not in progress requiring immediate and personal attention,—his vacations are few

in number and of short duration. In thirty-five years he has not taken a vacation of a month's time at one period. He has never visited the East but three times, and then only on hurried trips. He has been invited to go to Europe to be the guest of prominent scientific men, but he has never been able to accept on account of the length of time he would be compelled to remain away from his work. His recreations are few in number, but no one finds keener enjoyment than he in such ones as he chooses,— a small party of jolly friends, a visit to some friend in a near-by town, a romp with a little child, a day's wandering, at rare intervals, amidst the city's kaleidoscopic scenes, a long, strong tramp up the mountains, a day at the sea of which he is so passionately fond,— these are his chief stands for recuperation in the long, hard battle. And yet it is not a wholly apt figure; for his life is rather one series of noble triumphs, all adding to the sum of human happiness. He is particularly fond of the society of young people, and he is held in the highest esteem by them; with them he steadily renews his youth; he is of the type that never

grows old. All manner of fun appeals to him, but no fun,—so called,—over which there is not spread the sweetest delicacy.

In all his relations with others he is characterized by a winning gentleness. And yet he is swiftly roused at any show of deceit or sham. Kindliness, charity, modesty, tenderness; intuition; enormous capacity for work; unswerving devotion to a friend; intense absorption; unwearying application; steadfastness in his adherence to the right no matter how others may oppose, but with chivalrous tolerance of those who differ; a broad, cheerful outlook upon life, ever seeking to find the good and ignore the evil; a wide, deep sympathy for all that makes for uprightness in individual, civic and national life;—above all, the subtle soul of a poet joined to the throbbing heart of a man: these are among the attributes that mark the personality of Luther Burbank.

At times he is much given to epigrammatic speech: these are among many expressions:

"No man ever did a great work for hire."

"I hope that no one will ever be worse for my having lived

"Ignorance is the only unpardonable sin."

"The man who cannot say no, seldom gets the opportunity to say yes."

"The greatest happiness in the world is to make others happy; the next greatest is to make them think."

On the wall above his head where he sits at meat is a little placard which reads — the words from Emerson:

"Write it on your heart that every day is the best day in the year. . . . No man has learned anything rightly until he knows that every day is Doomsday. . . . Today is a king in disguise. Today always looks mean to the thoughtless, in the face of a uniform experience that all good and great and happy actions are made up precisely of those blank todays. Let us not be deceived, let us unmask the king as he passes."

No man could have done all the marvelous acts he has accomplished in the ennoblement of the earth unless he had had a deep, passionate love for all that is beautiful. Not all the years of unremitting study and research and tremendous toil have dulled, in the slightest degree, this love for the beautiful, whether it

be found in nature, or poetry, or art, or music, or in the rare blossoming of a human life.

The world will never seem quite the same to you, after you have seen this man in the midst of his lifework; the world will never be the same again, after his having lived in it; it will have sustained an irreparable loss on the day he shall say it good-bye.

CHAPTER XX

THE PLAN BOOKS

IT is doubtful if there is a single scientific man among the hundreds from this country and Europe, who have visited Mr. Burbank since his work became more widely known, or a single person among the many thousands of casual visitors, who ever heard of his plan books.

In conversation with a university professor who was much interested in Mr. Burbank's work, but who, in common with some others, doubted if he were "scientific," this question was put to him by a layman:

"If a man have great imagination, remarkable intuition, deep and wide knowledge, persistence, absolute sincerity; and if this man accomplishes what no other man or set of men has ever accomplished in a given department in the molding of old and the creating of new forms of life,— is this the furnishing of a scientific man?"

"In part,—such a man should logically be a scientist; but the records, how can he establish that what he has accomplished came through clearly defined lines? In other words, has he ample and well-authenticated notes and data to prove that what he says is true?"

"In answer, suppose that you have first his word for it that he has accomplished everything in certain definite ways,— "

"Yes," comes the interruption, "that is just the point, his word for it. Now, he may be absolutely honest, but ordinary men forget, they are influenced at a given point where their memory is not clear by something quite outside,—they become misty and they cannot tell how far they may be led astray. I find more and more in class-room work and in preparing material for publication, that I cannot rely upon memory."

"But suppose it is not an ordinary man, one who does not forget, who has a memory as marvelous as his works?"

"Granted; but let him try to prove that he followed a given course. How would Mr. Burbank, for example, prove to me that he took certain steps in a given test?"

Then came a consideration of the plan books of Mr. Burbank, the most curiously interesting documents perhaps ever kept by a scientific man, a complete refutation in themselves of the doubter;—the professor had never heard of them.

While these plan books were designed with no thought of scientific record as such, and are by no means such elaborate records as would have been kept had completeness been the aim, they are essentially and consistently scientific. They are a signal refutation of the contentions of a good many scientific men, who, like the university professor, have been unstinted in their praise of Mr. Burbank's achievements, but who have been unable to see their way clear to admit him to their charmed circle. Truth to say, though, in passing, they were all unaware that he, like all really great men in science, dwelt apart, beyond the walls of precedent and far across the stagnant moat of mere scientific record.

These plan books are a clear, adequate, comprehensive record of the chief events in the life history of every test of importance Mr. Burbank has undertaken. They are not

as full or as complete as he could have wished; time was not given and money was not at hand to provide for the recording of all the interesting minor details. It must steadily be borne in mind that this great work has been carried on at a constant financial loss, and that every available cent of money has been required for the actual expenses of the tests themselves. Still, in addition to all the demands upon him, he has kept up these plan book records year in and year out, recording in them step by step the essential larger details of the life he has been molding.

While they are curiously constructed, as unique as the man, they are definite, accurate, indisputable, scientific,—the most devoted adherent to scientific nomenclature could not have been more conscientiously accurate. Naturally, they were not made for the general public. They form a private record of the life history of the plants under test so peculiarly constructed, even though absolutely logical in their sequences, they would, in great part, be unintelligible without interpretation to any but the one who made them.

Mr. Burbank is in the midst of a great

test. Events of supreme importance in the many tests under way are happening,—things move with relentless rapidity. Certain data must be at once recorded. He has a pasteboard box at hand—he tears it to pieces, and on its brown surface in a bold, strong hand he makes his notation; or it may be on the back of an old envelope, or it may be in the field note-book he always carries in the midst of such work,—it matters not what the medium, the record is the thing, and it is made with all haste. It may be the turn certain sets of leaves are taking, departing in the hybrid from the ways of their ancestors; it may be the size or color or texture or date of ripening, or ultimate rejection of a fruit; it may be a record of the shape of its seed-cavity or an outline of its hemisphere; or it may be a note as to the tree trunk's development, or its departure from the normal, or some point of importance in the history of a graft, or the acidity, or sweetness, or uniqueness of the fruit itself. It may be the date of the opening of a flower, the length of its petals, the shape they assume, the height of the stalk upon a given date, the details of

its ancestry showing how and when its parents were bred and their names and those of their own forbears. So it goes throughout the whole life history of a given plant, be it berry or flower or tree or vine. All the facts are accompanied by dates, nothing is left to conjecture.

Generally the field record is transferred to the regular plan book, sometimes the information is preserved in its original form and placed between the leaves of the plan book, which holds many such loose sheets. A whole page in the plan book may contain data as to one test, sometimes continued to another page. The book for the Sebastopol tests is a large ledger nearly two feet in length. Any one of the pages containing data as to a given test is curiously interesting. It is covered from top to bottom with writing, dates and diagrams. These diagrams, or it may be mere ellipses or circles to enclose certain related facts, are usually drawn in red ink in the midst of the text. They may run out into the margin of the book, or they may be in the body of the page. They are irregular in form and location. They are, how-

ever, like a high-school scholar's grammar diagram, all logically connected. The page itself presents a strangely crowded effect, a veritable maze. I considered a sample page somewhat in detail, and found that it had forty distinct diagrams and figures and over six hundred words of text. Page after page of this matter appears. From time to time additions are made as the plant progresses. When the final test comes and the plant is finished, heavy cross-lines are drawn over the page — the end has been reached.

On one page is a large circle perhaps seven inches across. It represents the branch-spread of a tree. All over the circle are jottings showing where certain grafts are located on the tree, so that there can be no mistake. On the grafts, too, may be notations in the form of tags, but the record of the plan book shows absolutely where the graft is,—if the tag be lost, the record remains. Sometimes the notations are so many upon a page that the writing is well-nigh microscopic inside certain tiny squares that are drawn in red or black ink. Here are kept, too, absolute data as to crossings in hybridization. The parents on both

sides and their ancestry and the essential life history of the progeny are given; nothing is left to chance. Many a scientific man has been utterly at a loss to know how this man knew what he was doing: this is the first public mention ever made of the manner by which he makes the records which scientific men have believed lacking.

Now and then there will be a large open page on which will be a number of diagrams. or circles, all connected with each other and containing but a few words to each, showing how a certain plant has been bred up and what important facts developed in the course of its history. These diagrams are in red ink and the writing in pencil or black ink. When the end of a test is nearing and a certain plant has been selected,—it may be from among a hundred thousand, as the one best of all,—its record is accompanied by one or more large double crosses marked in deep black ink, which shows that this one plant is superior to all others.

When a fruit, for example, has reached the point that it appears to be worthy of record,—it may be a peach, chosen from ten thousand

seedlings or hybrids,—a page is given up to it. Here the method of record is extremely interesting and novel. The fruit is cut in half and laid in its fresh, juicy state upon the upper left-hand corner of the sheet. It is pressed firmly down upon the paper and a pencil is drawn around it, defining absolutely its size. There is no recourse here to a photograph or to a sketch,—he is after absolute fact, and the fruit is the fact. Another rapidly drawn line on the inside discloses the seed-cavity. I have seen one of these records where the stain of the fresh fruit had remained upon the paper for five years.

In the upper right-hand corner of the sheet is a name, some strange whimsical name which is used to identify the fruit until such time as it shall come up before the world in finished shape for its final christening. For a long time Mr. Burbank tried using numbers, but this proved impracticable, not only because of the liability to mistakes in transcribing but because the numbers became so large, on account of the extent of the tests, that they were unwieldy. One mistake in a number, also, might be fatal to the whole test. Again and

General view of the proving grounds at Sebastopol. Showing many thousands of plants under test

again in these plan books appears tne same persistent adherenee to accuraey, indeed to scientific aeeuraey, if you will, a supreme devotion to the definite. So, numbers not proving satisfaetory, he took fantastie names. Sometimes it is the name of a workman who is near at hand when the test is being made of reeord, but more often a peeuliarity of the fruit or flower itself. Here are some names seleeted from among many:

"Long Nose," "Pan Sweet," "Jim," "The Best Yet," "Christmas Giant," "Hill Top Sweet," "Weeping Yellow," "Rice Seed," "Snowball," "Old Juiey," "Beauty," "Left-over Sweet," "Miraele," "Giant," "Climax."

Now and then upon some page will appear at the end of a test two words; they sum up the results of perhaps a dozen years of testing: "No good." No matter how attraetive or how nutritious a new fruit, if it has failed to eome up to, and go a little beyond the fruits from whieh it was bred, it must be rejeeted, and the two words of supreme condemnation must stand forever against it.

As an illustration of the data on a given test, it may be noted that upon one sheet

devoted to a flower there were notes as to the character and substance of the petals; the number of the petals; the width of the whole flower; width of a single petal and its length measured to the one-sixteenth of an inch; the width of the central disc from which the petals spring, with its color; the average of a given number of blossoms; points as to the stem growth, and so on; with dates of observations and the like. For the next season there were similar notations showing what changes had taken place in the upward movement of the plant. One page was devoted to data as to a certain fruit,—when its buds appeared, when they began to swell, when they burst open, when the flowers came, when the fruit started, when it ripened, peculiarities and irregularities, and the like. On a page devoted to a certain lily test are close and accurate data as to the shape of the bulb at a given period, the description of the scales, their character, all the essential facts as to the condition at various stages of the test. Here and there will be other notations under date showing what other allied plants were doing at the same day, noted down for comparison

On a work of such colossal scale another point of definiteness can not be overlooked,—the precise location of the various plants under test. For this purpose there are concise memoranda showing where each selected plant is growing. Sometimes it will be a certain direction in so many feet from some certain fixed monument, as a tree, or a fence-post, or the corner of a conservatory, or what not. The plant, when it is finally chosen from among its thousands of fellows, is given a white streamer of cloth to distinguish it, and there are the usual inscribed stakes to identify it, but any of these might be destroyed and the plan books contain the definite means for determining just where the plant is growing. When so very many tests are under way at the same time and the aggregate number of the selected plants is so large, it becomes necessary to have precision and definiteness in some indisputable form.

Now and again, sheets will be found in which the stages of a plant's progress are indicated by large capital letters—A B C, and so on—distributed over the page and serv-

ing as quick guides to lead to any given step in the test. Everywhere throughout the plan books are notations showing the retrogression of a plant under test. Deficiencies no less than excellencies must be noted, in order that the life history may be complete.

One of the most interesting pages is that devoted to the cactus experiments, recording the kinds of cactus under test, how they were crossed, dates as to planting, points as to development step by step, and the like. Sometimes it will take an entire page to give the mere facts as to a plant's ancestry, showing in regular sequence the hybridizing steps it has taken, the region of the world from which it came, and the like.

The plan book for the preliminary tests at Santa Rosa, where much of the work has its beginning, is smaller than the Sebastopol book but none the less interesting. Here are recorded the earlier life-history events when the seeds are being sown and transplanted. Some of the pages of this book are an intricate maze of notations and diagrams, all presenting a bewildering mass of data to the on-looker but all clear and definite and instantly available to

The improved everlasting flower to be used in millinery

the man who made the records. In some cases the data of the Santa Rosa books are even more minute and particular than those of the larger tests.

Mr. Burbank has a good many such books as these, covering the experiments of many years, embracing many thousands of words of notation. For some years when he was struggling to make both ends meet, he tested seeds for eastern dealers, receiving ten cents for each variety tested. This was work requiring accuracy and record of the strictest type: like his records of after years, it was scientifically and commercially exact.

It will be seen, the more closely one studies the scope and sweep of this great work, that accuracy of record on essentials is imperative. A single error in this would throw out of gear, so to speak, the whole machinery of a test. The creator of the new fruit or vegetable or flower would be utterly unable to tell whether he was proceeding upon definite lines or running through a whole series haphazard, intermixing everywhere into other tests and rendering the whole invalid. First and above all, in a work of breeding carried on upon a

small scale, accuracy of record must be had; how much greater the need when the scope of the work transcends that of all the plant-breeders who have preceded him. A hint of the diversity that develops in a given test and a suggestion of the forces that must be kept in control and whose movements must be noted are seen in the fact that as much as a pint of pollen has been used in cross-fertilizing the flowers in a single lily test. The pollen from one flower would be not more than could be held upon the tip of a pen-knife blade, yet every one of the hundreds of thousands of plants that come from this gigantic crossing must come under the eye of the one who created them.

It should also be borne in mind that thousands of photographs have been made in the midst of the tests, and, while not so complete as the photographic records under the new order of things, they are yet important data in establishing the sequence of events. With the provision of ampler funds for the carrying on of the work, details will be recorded much more completely and the records will prove invaluable, both scien-

tifically and economically. But they will not be more strictly scientific, even in the eyes of the academician, than these records which have been kept of leading events in the life history of some of the most wonderful plants that even were given birth upon the earth.

If Mr. Burbank had taken time to answer every criticism of his work or methods made by pseudo-scientific men of inadequate knowledge, he would have wasted many days that have been given to the ennoblement of the physical earth upon lines as strictly scientific as those followed by the most distinguished scientists of this or any other century. But as real scientists have come to know the man and to study his methods, they have not hesitated to give him as great honor for his scientific attainments as for his marvelous accomplishments for the welfare of the race. I do not know that Mr. Burbank ever told any scientific man who ever visited him that he kept these plan books. It is more than likely that he never mentioned the fact; it is only an incident in his lifework. No doubt, had he given the matter thought, telling the scientific men that such records

existed, it would have been welcome information, an earnest to them of the scientific attainments of the man.

But the fact that he has kept records,—absolute and academic, if you will, even if far less complete than he would have wished,—this is not what gives him place in the ranks of scientists. To find reason for this rank we must look beyond the recording of data. Any man with keen eyes and a note-book may make records — the discovery of new truths and the interpretation of old ones, the destruction of errors, the illumination of earth's secret places, the extension of human knowledge,—these lie beyond.

CHAPTER XXI

THEORIES AND CONCLUSIONS

LOOKING backward over the achievements of Mr. Burbank, one might naturally be led to ask, What of the inner life of the man; has it, too, shown marked lines of development?

The physical life of the world has been changed by him as perhaps no other man who has ever lived has changed it. In his study of the subtler life of Nature he has arrived at conclusions and developed theories and disproved so-called laws in so significant a manner as to entitle him to consideration among the foremost thinkers of his generation.

No man, however prosaic by Nature, could share Mr. Burbank's life-long series of experiments in plant improvement and plant creation without being more or less attracted to and influenced by the inner life of Nature—the subtle, intangible, but none the less real life upon which man has been building

theories and laying out laws since the dawn of creation. To Mr. Burbank himself, with his highly organized, sensitive, intellectual life and his intense imagination, these subtle forces of Nature have been of absorbing interest. Through the light of experience he has seen with refined vision far into the strange, deep life whose outward manifestations have been the field of his life-work.

He has not studied in an extensive and expensive laboratory, nor confined himself to the comfortable atmosphere of a conservatory. In point of fact, he has had no laboratory at all, save that of the earth and the air and the sun. He has lived among no spectacular surroundings. He has had the seeds, he has had the generations of plants, he has had the earth; he has used these seeds and these plants and the earth as no man ever used them before.

The result has been that not only has he produced all these wonderful forms of life, but that, through the study of the inner life of Nature, he has arrived at conclusions radically different from some of those which may have been matured in the gentle atmos-

phere of the laboratory, or in the calm seclusion of the library. He has not been attempting to formulate any laws. He has not set out to overturn the conceptions of other men. He has carried forward his work with passionate eagerness for the truth. His creative work has been for the good of the world; his studies have also been for the welfare of man, never for the glorification of self. They have never been entered into with the spirit of the academician, or with any preconceived theories waiting to be put into laws. Plain, old-fashioned truth has been his seeking: If, in reaching the goal, he has been obliged to cast aside some of the impedimenta of the scientists, it has not been in anger, but because of haste.

Very early in his career, even when he had but begun his preliminary business life, two words ever rang in his ears, How? and Why? Day by day he sent these words forward into the hidden realm of Nature, and day by day they came back to him laden with answers. How came it that a certain plant upon which he was conducting a given experiment had gathered to itself certain

attributes through centuries of life, while, at the same time, as steadily rejecting other attributes; just as successive generations of a given family gather and reject certain family traits? How much of it was heredity, how much of it environment, how much a direct mingling of these two, how much, if any, could be traced to neither?

And then the other word, Why? Why was all this done, and why was it all so persistently veiled from human eyes?

In the midst of the exacting toil as he worked among his plants, this constant study of Nature broadened his mind. Year by year his sight became more refined, his knowledge deeper. He read much upon the subject, particularly Darwin. He made the most careful study of the conclusions reached by other men who had sought for the secrets of Nature's life, and how they came to these conclusions. Sometimes noting that certain improbable conclusions had been reached from certain premises, he set to work to discover the soundness of the premises, only to find that they were unsafe to trust. He early discovered, also, that some of the men

whose rank was highest in the departments of science most nearly related to his work came to their conclusions from inadequate data.

For example, one man would arrive at a certain conclusion, or law, if he chose so to designate it, from the facts developed in a series of experiments with a dozen plants, carried on in a garden or a conservatory. Possibly, from the study of these plants, their habits, their changes under breeding and selection, these conclusions would be held absolute and applicable to a far wider field than that in which these few individuals were found. Working with the same plant, a flower or a fruit as the case might be, Mr. Burbank arrived at absolutely opposite conclusions. But, in place of a dozen plants, he used a hundred thousand; in place of a corner in a garden or a narrow space under the glass of a hothouse, he used an acre of ground in the open; in place of a dozen distinct plants from which to make conclusions, he dealt with over three thousand species; and thus he was able to command an outlook broader than man had ever

had before. Willing at all points to yield the moment he was convinced of error, it was yet inevitable that his own sound judgment should tell him that when his vast experiments developed results diametrically opposed to the results of the scientists working in circumscribed quarters, he was bound to stand by his own. Twelve plants in a given test might do certain things in concert and thus apparently establish a law, but a hundred thousand plants, indeed, sometimes a million plants, in the same test by developing absolutely contrary conclusions, utterly set at naught the significance of the twelve. This may very clearly be seen in the results of his observations along the lines of the so-called Mendelian Laws.

Mendel, a parish priest in Brün, Austria, a devoted student of botany, prepared a paper in the year 1865 in which he showed, as a result of his years of investigation, that certain laws were bound to obtain in the breeding of plants. When two peas, for example, were crossed, two prevailing sets of characters or characteristics were developed. One of these he called "dominant," certain

prominent characteristics of the parent disclosed in the offspring, as color of flower, length of stem, shape of leaves, form of seed, arrangement of flowers, and so on. Certain other parental characters he called "recessive," appearing in lesser number in the new plant, or disappearing altogether. These characteristics appeared in the offspring in an invariable ratio, that of three to one. Seventy-five per cent of the characters of the new plant,—form, color, development and so on, would be "dominant," twenty-five per cent would be "recessive." The recessive characters thereafter bred true, but the dominant ones produced progeny one-third genuine dominant,—which also bred true to their own type, and two-thirds cross-breeds, the latter, when self-fertilized, giving out the old ratio of seventy-five per cent "dominant" characters, twenty-five per cent "recessive."

These "laws," so-called, would provide means for determining in advance what results would follow in the breeding of plants; and, if carried forward into animal-breeding, would be of inconceivable value. Quite generally throughout Europe these

laws have been accepted by the scientific world.

Over and over again, through a series of many years, dealing with millions of plants and upon a scale which dwarfs all other experimentation, Mr. Burbank has shown the total inadequacy of these "laws." At his home in Santa Rosa stands a row of walnut trees, already referred to. These may be taken as a fair illustration of the manifold facts bearing on the points which have been developed by him. Instead of following any set proportion or ratio, the parental characteristics appeared in the children with absolutely no regard for law or even order, while many new characters were developed. Thousands of different forms were assumed by the leaves, for example, absolutely unlike the forms of the parent leaves. The nuts which came from the new trees were often wholly unlike those of either parent; indeed, very frequently, they were wholly different from any walnuts ever known before. Sometimes there were five leaves on a stem, sometimes twenty or thirty, sometimes fifty. Many assumed, too, a most delicious fragrance, a character wholly

lacking in either of their forebears. Nor did the new trees show any similarity in growth to the old, a new tree in thirteen years having grown six times as large of girth and six times as tall as the parents had grown in twenty-eight years.

Here, as in hundreds of cases all through his career, the "laws" have been shown not to apply, save in rare instances, by the evidence accumulating in the tests carried on upon so colossal a scale. The old laws were announced upon much such reasoning as this: Here are ten or twenty or even a hundred men; a certain number of them will yield to temptation of a certain type, a certain other per cent will stand fast: seventy-five of a hundred children born of vicious parents will grow up scoundrels, twenty-five per cent saints. The instances, for illustration, develop as predicted, but outside the hundred examples lie ten million others, influenced, as in the case of Mr. Burbank's plants, by a million hereditary tendencies and a million events of environment leading to totally different ends, setting at naught the inferences to be drawn from the hundred.

He would welcome, with the eagerness of any lover of truth, any confirmation of law, for his whole life is pledged to law. He had no ulterior purpose in disproving the Mendelian laws: in point of fact, he had disproved their universal applicability years before he knew they existed.

Mr. Burbank, in another instance, has brought to light the absurdity of reasoning from inadequate data. Leading scientists have maintained, and their followers have added the weight of their evidence, that "acquired characteristics are never transmitted." In the limitless fields of operation before him, Mr. Burbank has not only disproven this over and over again, but has established the opposite, that acquired characteristics are the only ones that are transmitted.

Another theory, now widely accepted by scientific men, the theory of mutation, or saltation, new forms of life being produced by springing from the parents by a sudden leap or bound, evolution thus going on by rare and sudden leaps, appears to have been overthrown by Mr. Burbank. Instead of

Leaves of blackberry hybrid, all grown from seed of one plant, showing the remarkable variation

any law or other force governing these peculiar mutations,—which mutations, it has been held, produce new and stable varieties from which Nature selects those which are fit,—Mr. Burbank, times without number, has produced these strange mutations at will. They can be produced, he says, by anybody who systematically sets to work to disturb the life habits of the plants. Thus the peculiar phenomena which scientific observers on a small field have so sedulously studied, and have at last come to consider the result of a supreme act of Nature, are entirely within the province of any market-gardener or amateur plant-breeder. In addition to this, he has demonstrated that that which the scientists have called mutations are not *periods* in the plant life at all, but only *states* or *conditions*, the result of hereditary tendencies and environments.

Putting the matter in condensed form he says:

"By crossing different species we can form more variations and mutations in a half dozen generations than will be developed by ordinary variations in a thousand generations."

It is but natural that out of all the intimate relationship he has borne to Nature and out of all his many years of intense study of her inner life upon so grand a scale, he should have reached certain well-defined theories. One of these pertains to heredity, a term at best vague, which has been loosely held. Out of the years of his investigations, carried on upon such a colossal scale, he has established the principle that heredity is "the sum of all the effects of all the environment of all past generations, on the responsive, ever-moving life forces; or, in other words, a record kept by the vital Principle of its struggle onward and upward from simple forms of life; not vague in any respect, but indelibly fixed by repetition."

He condenses this into the statement: Heredity is the sum of all past environment.

Heredity now becomes something far different from what it had before been held to be. "Every plant, animal and planet," he holds, "occupies its place in the order of Nature by the action of two forces,—the inherent constitutional life-force with all its acquired habits, the sum of which is heredity;

and the many complicated outside forces or environments. To guide the interaction of these two forces, both of which are only different expressions of the one eternal force, is, and must be, the sole object of the breeder, whether of plants or animals."

He speaks of a vital Principle. He does not attempt to establish its essence or identity, but he says:

"When simple cells become joined together, mutual protection is assured, and we know that they exhibit organized forces in new directions which were impossible by any of the individual cells not associated in a cell-colony with its fellows. These cell-colonies will, if environment is favorable, increase in strength, while colonies less favorably situated may be crippled or destroyed. We see this natural selection in all life, every day all around us. But this is only one of the many forces at work in the upward, outward and onward movement of life."

Other men who have gone deeply into the inner life of Nature have given the world elaborate systems by which to account for and interpret many of the acts of Nature.

It seems but fair to say that very much of these systems has been built up upon a slender base of experimentation. From his unparalleled opportunities of observation he arrives at certain conclusions. He does not ignore the Survival of the Fittest or the principles of Natural Selection, but he goes beyond them. The grand principal cause of all existing species and varieties of earth, sea and air, he holds to be the Crossing of Species. Upon this point he says:

"The very existence of the higher orders of plants which now inhabit the earth has been secured to them only by their power of adaptation to crossings, for through the variations produced by the combination of numerous tendencies, individuals are produced which are better endowed to meet the prevailing conditions of life. Thus, to Nature's persistence in crossing do we owe all that earth now produces in man, animals or plants; and this magnificently stupendous fact may also be safely carried into the domain of chemistry as well; for what are common air and water but Nature's earlier efforts in that line, and our nourishing foods

but the result of myriad complex chemical affinities of later date?

"Past tendencies must fade somewhat as the new ones are added, and as each individual has ancestors in untold numbers, and as each is bound to the other like the numerous threads of a fabric, individuals within a species, by thus having very numerous similar lines of heredity, are very much alike; yet no two are just alike. Cross two species and see what the results will be: Sharp mutations and variations appear, not in the first generation, as the two are bound together in a mutual compact, which, when unloosed by the next and succeeding generations, will branch in every direction as the myriad different lines of heredity combine and press forward in various new directions. A study of plants or animals belonging to widely different species and even genera which have been under similar environment for a long time will always show a similarity in many respects in the various means they are compelled to adopt for defense in the preservation and reproduction of life. Desert plants often have thorns, acrid qualities and

reduced foliage surface, while in moist climates thorns are seldom seen, and foliage is more abundant and not so often acrid or distasteful. Similar environments produce similar results on the life-forces, even with the most distantly related plants or animals. This fact alone should be proof enough, if proof were still needed, that acquired characters are transmitted, even though in opposition to numerous popular theories. All characters which are transmitted have once been acquired. The life-forces are constantly pressing forward to obtain any space which can be occupied, and if they find an open avenue, always make use of it, as far as heredity will allow."

In this new century the new man comes, discarding the narrow canvases of the studios, and, upon the great canvas of the earth itself, he traces the supreme function of Nature, the Crossing of Species; and with this, the working of a vital Principle eternally recording Heredity, that sum of all past environments. He sees all Motion, all Life, all Force, all so-called Matter, following the same law of heredity in plant- and animal-

life, a forward movement toward attractions, through lines of least resistance.

Summing up, he says:

"My theory of the laws and underlying principles of plant creation is, in many respects, opposed to the theories of the materialists. I am a sincere believer in a higher power than man's. All my investigations have led me away from the idea of a dead material universe tossed about by various forces, to that of a universe which is absolutely all force, life, soul, thought, or whatever name we may choose to call it. Every atom, molecule, plant, animal or planet, is only an aggregation of organized unit forces, held in place by stronger forces, thus holding them for a time latent, though teeming with inconceivable power. All life on our planet is, so to speak, just on the outer fringe of this infinite ocean of force. The universe is not half dead, but all alive."

CHAPTER XXII

HIS PLACE IN THE WORLD

IF it be difficult accurately to assign a man to his final place in the world within a generation, or even a century, of his death, it is far more difficult properly to locate him while still in the flesh. At the same time, if the deeds done have been apart from those of other men, and of commanding significance, without duplication in their sweep in history, we may, by some consideration of his accomplishment and some setting forth of his mental furnishing, fairly suggest something of the estimate posterity may place upon him.

First among all other things, Luther Burbank is unique among men in his knowledge of Nature and in his manipulation and interpretation of her forces. Other men have been plant-breeders and have produced remarkable results in improved fruits and flowers. They have achieved a merited reputation; indeed, in some cases this high reputation has passed on

into a certain measure of fame. Some of these have been working along strictly scientific lines, others have been enthusiastic horticulturists or seedsmen, preëminently practical and using agencies to reach certain desired ends without thought of the *rationale* of their actual instruments and methods, or any estimate of the forces at work. These latter men are artisans in plant-breeding, building in many a case beautiful and important works.

But Mr. Burbank has not only created plants and improved them upon a colossal scale, but he has, at the same time, studied nature with infinite patience and skill, observing her manifestations, analyzing her laws, and defining and interpreting her functions. His life-work has been primarily two-fold in its sweep: First, embracing the widest possible service to the world; and, second, accomplishing this service under the most exacting and persistent adherence to scientific truth. He is, in his department of life, scientist and philosopher and plant-breeder and horticulturist bound into one. He has not confined his study, as other men have, to a narrow field. All the great experiments he has carried on

are in a certain sense similar in character, but, at the same time, each is different from each other one and each one leads into new and untrodden paths. He is preëminently an observer as well as a man of rare intuition and wonderful power of memory. He not only notes those essentially obvious characteristics which the average man may see, and assigns them unerringly to their proper place, but he looks further on and deeper into the subtler life of nature and, as unerringly, assorts and eliminates and assigns. He adds all these manifestations of nature to the sum of all his experiences, and from them all he draws for his material for his own mental furnishing and equipment.

I have ridden with him over the road to Sebastopol on fair winter days when the earth was green and beautiful, and have many a time been struck by the swiftness with which he would turn from the discussion of some deep problem of human life to note the peculiar brilliancy of the song of some early linnet in the hedge; or to point out the fact that the crimson-winged blackbird on the fence was tardy this season

in putting on his colors; or to call attention to some peculiarity of a parasitical moss growing upon a huge live-oak; or to point out how a certain piece of roadmaking in progress should be done to secure the best results for economy or permanancy; or swiftly to note some geological sign along the way that proved the theory that this beautiful valley hard by the Pacific was an arm of the sea not longer ago than the day in the winter of 1577 when Sir Francis Drake, harassing many seas upon his buccaneering voyages, sailed over the very ground we were traveling over on his way up the great bay of San Francisco. Then swiftly backward his thoughts fly to the subject under consideration,—perhaps the elusive but fascinating phenomena that have their manifestation in the acts of the subliminal self, or the curious coincidences of mental telepathy, or the survival of the soul after death, or some acute problem in sociology, or some topic broadly religious or humanitarian. In any such discussion, one must steadily be impressed by the clarity of his mental vision, by the neatness and precision of his language, by the cogency of his thought.

It has become the academic fashion to take the ground that, unless a man is a man of record, unless he keeps a close and systematic note-book, so that at any given time he can refer authoritatively to any given step in a given research and show precisely what the conditions and what the tendencies at that moment, he cannot be classed a scientist. In the unusual sweep of his lifework, unusual in its results as well as in his understanding of its inner life, Mr. Burbank has steadily set at naught this contention. He has not kept such records of his work as should have been kept, — and no one better than himself knows and laments this fact,— such records as his larger opportunities now provide; but the keeping of these records in the past would not have made him a scientific man,— they are incidental, even if important. He has not disdained records, he simply has not had time to make them himself or money to hire others to make them, and yet in his plan books, elsewhere noted,— books which probably not one man in ten thousand who has visited him ever heard of,— he has been eminently scientific, even from the standpoint of the academician

One of the few double hybrid clematises

But, in considering Mr. Burbank's place in the world, it must steadily be borne in mind that he is primarily not a mere recorder or reporter of facts. Two men stand in the presence of a great historic event, it may be the signing of a treaty for international peace, or the elevation of a prelate of the church, or the inauguration of a president, or the crowning of the King in the historic Abbey by the slow-moving Thames. One man carries a camera, the most perfect of its kind, ready to reproduce everything that transpires, accurate to the verge of painfulness. The other is making mental, and, so far as may be, manual sketches upon paper, the basis of future action; one is a photographer; the other a painter. One gives a record of the event, exact to a nicety, perfect in detail, truthful in outward exposition, but as devoid of soul as the sensitized plate upon which the scene is printed; the other paints a masterpiece in which the splendid scene reappears in its proper perspective with non-essentials eliminated, with essentials in proportion, and, over all and through all, the very soul and spirit of a noble historic

event. One records, the other creates; one is the perfection of mechanism, the other is the incarnation of truth; one is purely and everlastingly material, the other is as everlastingly spiritual.

The average so-called scientific man, the one who has made the course of the university with distinction, but who puts his knowledge to no higher purpose than to record certain facts which he accumulates and tries to set in logical sequence beyond certain other facts, is an important man in the construction of the framework of science, but, slightly to change the figure for consistency's sake, he is the photographer, the recorder, while Mr. Burbank and every other man along down the long line of noble descent, the clans of Darwin and Spencer, and Huxley and Tyndall,—is the painter, the creator.

Reference has been made to Mr. Burbank's attitude toward modern education. It should not be thought that, because he has not had a university training, therefore he is inimical to such training. It is not the training in itself that he antagonizes or deplores, but

the character of the training, often, to his mind, in the department to which he has given his life, fatally deficient, tending toward artificiality and veneer, as well as toward a certain specialized one-sidedness. He has taken his place in the world on this point alongside many other men of prominence who are now secretly or openly opposed to certain superficial tendencies in modern educational life, and stands for such a revision of curricula as shall leave the average college and university graduate master of certain essential fundamentals of which too often he is lamentably ignorant. In discussing the moral and religious influence of science, Herbert Spencer takes occasion to quote Tyndall on inductive inquiry, and the latter's words are so illustrative of the life of Mr. Burbank that they are here quoted:

"Inductive inquiry requires patient industry and an humble and conscientious acceptance of what Nature reveals. The first condition of success is an honest receptivity and a willingness to abandon all preconceived notions, however cherished, if they be found to contradict the truth. Believe

me, a self-renunciation which has something noble in it, and of which the world never hears, is often enacted in the private experience of the true votary of science."

The recognition of Mr. Burbank was at first slow because he has steadfastly refrained from courting publicity, but it has proceeded upon steadily advancing lines. One of the most satisfying public acts in his career so far, because it was an act of his fellows, was the striking of a gold medal in his honor, in May, 1903, on the part of the California Academy of Sciences, a notable body of western men. It was the date of the fiftieth anniversary of the establishment of the Academy. Mr. Burbank was chosen as the one whom this commemoration medal should honor. On the obverse of the medal are the words:

> California Academy of Sciences
> Awarded to
> **Luther Burbank**
> For Meritorious Work in Developing New Forms of Plant Life. May 18, 1903

On the reverse is a design of the goddesses Pomona and Flora placing a laurel wreath upon the head of a young man engaged in budding a fruit tree.

He has received visits from many of the leading scientific men of two hemispheres, who have been generously appreciative of his great work, as well as thousands of calls every year from people in other walks of life from many different countries; he has received letters from great men throughout the world, among them a number of crowned heads, some speaking words of praise for his scientific achievements, some bearing eloquently upon his service to mankind; he has been given many recognitions at county, state and worlds' fairs; he was elected the first honorary member, out of a possible ten, of the Plant and Animal Breeders' Association of the United States and Canada; he is a Fellow of the American Association for the Advancement of Science and an honorary member of numerous scientific societies; the degree of Doctor of Science has been conferred upon him by Tufts College; he is a lecturer on scientific plant-

evolution in Leland Stanford University; he has been granted a subvention of a hundred thousand dollars by the Carnegie Institution. He has not attempted to fathom all the depths that Nature holds, but he has so sounded those depths he has selected for investigation, and so set his life to the advancement of the world, that his place must not only be a noble one today, but a still more commanding one tomorrow. It is not too much to say that volumes could be prepared from the newspaper references to Mr. Burbank made in the past year or two. The following quotation from a New Jersey newspaper, the "News," of Newark, may be taken as a fair summing up of the more serious popular estimates of his life and achievements:

"Luther Burbank,— until recently an unknown name,—has bestowed upon the world a greater increment of values, in things done and things inevitable, which are for the permanent betterment of civilization, than any score of celebrities in this decade or in any previous decade or century, when the fact is submitted to ultimate analysis. He

has produced more new plant-life, fruits, grasses, trees and flowers, than any other man who has ever lived. He has done with an intelligent purpose, clearly grasping its end and on a large scale, what a few have done accidentally or capriciously, on a small scale. He comes nearer to being what may be called a creative mind in the product of organic growth than any other scientific worker on record. . . . His name is bruited today all over the civilized world. Hundreds of able experimentalists are no doubt eagerly following in the path he has blazed. What science will accomplish, thus set in motion, the wildest imagining may easily fail to grasp. The reflex of all future achievement will throw back its glory to brighten Burbank's aureole, for he will have been the master and protagonist. Is it too much to say that among the great benefactors of their race Luther Burbank will be unique in the splendor of his monument? That can never crumble while sunshine, air and soil carry on their chemistry."

Hugo de Vries, the Dutch botanist, when in this country in 1904, said of Mr. Burbank

at a banquet which he attended in San Francisco:

"The flowers and fruits of California are less wonderful than the flowers and fruits which Mr. Burbank has made. He is a great and unique genius. The desire to see what he has done was the chief motive of my coming to America. He has carried on the breeding and selection of plants to definite ends. Such a knowledge of Nature and such ability to handle plant-life would be possible only to one possessing genius of a high order."

That which distinguishes Luther Burbank is four-fold in its bearing—

1. He is unique in his knowledge of Nature and in his physical manipulation and interpretation of her forces.

2. He has already accomplished in his chosen line of life more than any other man who has ever lived; indeed, when the full sweep of all his achievements shall finally come into view, it may not be unfair to say that not all the plant-breeders who have preceded or accompanied him have done so much for the world. He has done more in a generation in creating new and useful types of

plant-life than Nature, unaided, could have done in a millenium,—more, indeed, than Nature, unaided, would ever have accomplished.

3. His direct influence upon the physical character of the world is no less significant than his influence upon his contemporaries.

4. He is not only a great power in the physical manipulation of Nature, but he is a deep and accurate thinker and a man of indisputable scientific attainments.

I cannot better conclude this necessarily imperfect showing than by the following by David Starr Jordan, president of Leland Stanford University, in answer to a request as to the place of Luther Burbank in the world:

"It seems to me that Mr. Burbank, while primarily an artist, is, in his general attitude, essentially a man of science. Academic he doubtless is not, but the qualities we call scientific are not necessarily bred in the academy. Science is human experience tested and set in order. Within the range of molding plants, Mr. Burbank has read carefully, and thought carefully, maturing his

own generalizations and resting them on the basis of his own knowledge. Within the range of his own experience he is an original and logical thinker, and his conclusions are in general most sound. He is not a physiologist, still less a histologist, and the phenomena of heredity as shown in cell-division and cell-multiplication he has not studied for himself. The researches of Weismann and those suggested by his theories of heredity Burbank has given little attention to, and he has, therefore, a confidence in the inheritance of acquired characters, such as effects of environment, which most biologists of today do not share. On the other hand, many of the best of them would fully agree with Burbank.

"In his field of the application of our knowledge of heredity, selection and crossing to the development of plants, he stands unique in the world. No one else, whatever his appliances, has done as much as Burbank, or disclosed as much of the laws governing these phenomena. Burbank has worked for years alone, not understood and not appreciated, at a constant financial loss, and for this

reason,—that his instincts and purposes are essentially those of a scientific man, not of a nurseryman nor even of a horticulturist. To have tried fewer experiments and all of a kind likely to prove economically valuable, and finally to have exploited these as a nurseryman, would have brought him more money. In his own way, Burbank belongs in the class of Faraday and the long array of self-taught great men who lived while the universities were spending their strength on fine points of grammar and hazy conceptions of philosophy. His work is already an inspiration to botanists as well as horticulturists, opening a new line of research in heredity, as well as a new field for economic advance. Already his methods are yielding rich results in the hands of others. We shall, by such means, find much more than we now know of the evolution of organisms, while the improvement of organisms for the use and pleasure of man is yet in its infancy.

"Scientific men belong to many classes; some observe, some compare, some think, and some carry knowledge into action. There is need for all kinds and a place for all. With

a broader opportunity, Burbank could have done a greater variety of things and touched life at more points; but, at the same time, he would have lost something of his simple intensity and fine delicacy of touch,—things which the schools do not always give and which too much contact with men sometimes takes away.

"Great men are usually men of simple, direct sincerity of character. These marks are found in Burbank. As sweet, straightforward, and as unspoiled as a child, always interested in the phenomena of Nature, and never seeking fame or money or anything else for himself. If his place is outside the temple of science, there are not many of the rest of us who will be found fit to enter."

All that Luther Burbank has received,—observation of the keenest type, unsurpassed intuition, knowledge, understanding, scientific attainment, in a word, genius of the highest order for the interpretation of the work to which he has devoted his life,—he has accepted as a sacred trust, not to be dissipated but to be administered with unswerving fidelity to the common interests of mankind.

CHAPTER XXIII

THE NEW OPUNTIAS

BEFORE presenting somewhat in detail the inception, development and culmination of the thornless opuntias,—in some ways the most important work Mr. Burbank has ever accomplished,—a word of explanation on one point seems needed. Several years ago it was Mr. Burbank's hope that the cactus, which promised to regenerate the waste places of the earth and provide a new food for man and beast, might be given to the world free of all cost. All through his life, as has been set forth in these pages, the ruling principle has been sharply defined: How may the greatest good be done to the greatest number? It is a day when no harm will follow laying special emphasis on such a principle. Having received a liberal subvention from the Carnegie Institution for the furtherance of the work, it would naturally follow that he would thus stand relieved of care and able to avail himself of

that ease and personal comfort which money brings.

But when the balance of the first year under the subvention, recently closed, was struck, it was found that Mr. Burbank had not only put back into the work the amount set apart for the maintenance of the tests under way and projected, had not only added to this the amount which was to be set apart as his own salary, but had expended in the carrying forward of the larger work some six hundred dollars additional out of his own pocket. In other words, he had given up his salary and drawn upon his own funds as well.

When it came to the distribution of the cactus, which had cost heavily during the twelve years it had been under test, it was found that, with all the other attendant expense pressing heavily upon him, it would be impossible to carry forward this work without special remuneration. For this reason the cactus was placed on sale. Had he wished to make money out of the new cactus, it would have been a very simple act to organize a modern corporation, provide for promotion facilities, restrict production, maintain prices,

and control output, squeezing out of the enterprise every dollar it would yield. A fortune could thus have been made, and perhaps, to some, it would seem a logical and legitimate enterprise. But it would not have been Mr. Burbank's way of doing things; it would have been to stultify himself.

As there are no monopolistic restrictions upon the output, and as the cactus is of such remarkably rapid multiplication and growth, it will be but a comparatively short time before it will be the property of the world. It is interesting to note in this connection that, through the generous offer of an Australian for the right to introduce the cactus into that country, Mr. Burbank has been enabled to build that which he had never had before, a comfortable house in which to live,—the Australian paying three thousand five hundred dollars for five leaves.

It was in the period that marked the great change in his life from a prosperous nurseryman to the career of a scientific plant-breeder that Mr. Burbank first began a practical consideration of the possibilities of the cactus. As has been indicated in the chapter dealing in a

general way with the cactus, he had been interested in the plant from a child; something in its wild, stubborn, defiant life appealed to him. This was greatly strengthened as the years went by, and as he saw its tremendous economic possibilities.

The problem before him, as he set out his first cactus plants on the morning of a fair June day, was one of the most difficult ever faced by a plant-breeder; in certain ways it might be called the most difficult. It is doubtful if Mr. Burbank himself, at the beginning of this long and signally successful experiment, realized the magnitude of the task before him, or the vast possibilities. While at that time it was known that there were thornless cacti, they were of relatively small economic value to the world. The insignificant bristling little pests, with which he began the test, gave no promise in themselves of the splendid creations which are today the fulfilment of one of his most cherished plans.

It was in the midst of a study of forage plants and the possibilities of their improvement,—various grasses, native and foreign, wild and tame, a line of work still under way,

—that his attention was attracted to the cactus. If he could take the cactus, possessed of unquestioned excellencies as a forage plant, as well as being of marked edibility for man, and convert it, man's implacable, defiant foe, into man's obedient servant, the problem would be solved.

He selected, as the cactus on which to begin work, the opuntia, named from a city called Opus, in Locris. The particular plant upon which he first began work was the common prickly pear (*Opuntia vulgaris*). Concerning the opuntia, Mr. Burbank says that he was early impressed with its possibilities, when combined with other species, because of its hardiness, its vigor, its rapidity of growth, and its ability to adapt itself to a wide variety of conditions. So he set about securing from all over the world different varieties of the opuntias. Mexico, Central and South America, North and South Africa, Japan, Australia, Hawaii, and the South Sea Islands were drawn upon for a working stock. Hardy wild species were secured also from various parts of the United States. He drew liberally upon species far different from the opuntias for the

purpose of building up his ideal strain. No matter how wild and defiant, no matter how full of deadly thorns, if he saw in them some characteristic likely to have a helpful influence, they were installed upon the proving grounds. Quoting Mr. Burbank in this point:

"Many so-called thornless or partially thornless opuntias were obtained, but not one among the thousands received from all these sources was absolutely free from thorns and spicules; and, even worse, those which were the most promising in these respects generally bore the poorest fruit, were the most unproductive, provided less fodder, or were less hardy than the wild thornless species and varieties. The first work was to select the best of these, and thus continue, hoping for improvement. One of the first and not unexpected facts of importance to be observed was that, by crossing, the thorns were often increased rather than diminished, but not so with all. Some very few still came even more thornless than their so-called thornless parents, with greatly increased size and quality of leaves (known by some as raquettes, or slabs), and among them was a combination of the

best qualities of both parents, with surprising productiveness.

"Some of the best growers among the new opuntias produced three or four times as much weight of food per acre as did the wild thorny ones under exactly the same conditions. But, better yet, hardy ones were produced, which will already withstand five to ten degrees more freezing than others of the wild type. This was not unexpected, as the opuntia is surprisingly variable even in the wild state. The best botanists,—even those who have made the opuntia a special study,—declare it to be one of the most difficult genera to classify, as new forms are constantly appearing, and the older ones so gradually and imperceptibly merge together. The facts, without doubt, are that their ancestors had leaves like other vegetation and were as thornless as an apple tree, but in ages past were stranded in a region which was gradually turning to a desert, perhaps by the slow evaporation of some great inland lake or sea. Being thus stranded, those plants survived which could adapt themselves to the heat and drought, each year, as the seasons passed, becoming more

severe. At first they accomplished this by dropping all of their leaves, thus preventing too much evaporation, while the fat, smooth stems were left to perform the functions of the leaves. The opuntias to this day always shoot out numerous rudimentary leaves, which persist a few days or weeks and then, having no function to perform, drop off.

"But the opuntia had yet to meet another enemy. Desert animals were hungry for their rich stores of nutriment and water, so the rudimentary leaves were replaced by awful, needle-like thorns, placed at exactly the right angles for defence and, at the base of these, partially imbedded in the stems (now leaves) were numerous bundles of smaller needles, more than ten thousand to each leaf. These are even more dangerous than the larger needles, producing great pain, inflammation, and at last death, to animals which were pressed by starvation to consume them for food.

"The opuntias having once been thornless, there was no reason why they should not again revert to a state of partial thornlessness, and this is precisely what they do. In the Hawaiian Islands a partially thornless opuntia is

sometimes found, always growing, however, in places absolutely inaccessible to browsing animals. In California, Mexico, Colorado, New Mexico and Texas, small patches of half-thornless ones are sometimes found, almost always in inaccessible crevices among the rocks. On some of the South Sea Islands, where vegetation is abundant and browsing animals few, the opuntias, having no use for thorns, have become hair-like, diminished and perfectly harmless."

From year to year, as the test has advanced, Mr. Burbank has had occasion to draw upon the following cacti, which, with others, have formed the groundwork of this great experiment,—the list will suggest something of its scope, as well as its complexity:

General varieties,—Albispina, arbuscula, arborescens, basilaris, Bernadina, Brasiliensis, camanchica, dearmatus, Emori, Englemanni, formidablis, frutescens, fulgida (cholla) fragilis, galopageana, gummosa, humifusa, lævis, leptocaulis, lurida, Missouriensis, monacantha, macrorhiza, nigricans, papyracantha, phænacantha, Rafinesquii, senilis, spinosoir, triacantha, ursina, and others.

Opuntia Tuna—Amarillo, blanco, cardena (U. S. 10179), chasena, colorado, crystallina, grande, jarilla, morado, tapuna, xoconostle, vulgaris, and others.

Opuntia Ficus Indica—Anacantha (U. S. 9352), Arizaga (white), Arizaga (yellow), blanco, Bryant, catania (U. S. 3642), colorado, gymnocarpa (U. S. 12402), Hayne, inermis, malta (U. S. 9352), maurisi (U. S. 9850), mission, monelova, Myers, Skelley, Watson (No. 1) Watson (No. 2) and others.

In addition to these, plants of Nopalea, Cercus, Pilocereus, Mammillaria, Echinopsis, and Phyllocactus have been used in the tests with twelve thousand seedlings and hybrid seedlings, the offspring of the hardiest, most nutritious and most rapid-growing so-called thornless varieties.

Passing to more definite details, as to the development of the opuntia, and the part it is to play in the redemption of the waste places of the earth, it is to be noted that the cactus plant differs markedly from many other plants in the facilities which it offers for breeding. For example, it must be pollenated in the very middle of the day, in the hottest sun-

shine of the hottest summer months. From a half-hour to two hours and a half the blossoms are then in fullest bloom. Particular care was found necessary in the crossing to see that no possible trace of vagrant pollen was upon the stigma of the plant to be crossed with pollen from another. Every step in the great work must be safeguarded. Thousands of pollenations were to be made; all of them must be made by skilled men; only a brief portion of each day and but a short portion of the year was available for the work.

The cactus plant first opens its blossom and presents its stigma for pollen from insects. It has learned this habit through age-long processes. When a certain time has elapsed, however, and no insect comes along bearing the fructifying pollen on leg or wing, the stamens of the plants can wait no longer, and, bursting forth, they sift their golden secret down upon the receptive stigma and pollenation has begun. It is at this particular period when the plant is waiting for the insect that the breeder must be prepared for his work,—no detail can be overlooked, everything must be in readiness.

It will thus be seen that not only is the time for crossing the cactus restricted to a very few days and a few hours of each one of these days, but that only a very short portion of such daily period may be used. So all possible haste in the work consistent with accuracy is imperative.

First securing from the plants to be crossed with those in waiting a sufficient amount of pollen, thoroughly distributed through camel's-hair brushes, the stigma is examined with a powerful hand microscope to make absolutely certain that not a single pollen-grain is upon the stigma. One such pollen-grain at this juncture would defeat the whole pollenation. Should such a grain be discovered, it must be removed at once; if this cannot be done, the blossom must be abandoned. With the stigma clear, the pollen is dusted thickly upon it: the initial act is ended, though the real end of the test be years distant; for from the seeds of this pollenated plant other plants must be grown and still others, thousands of them it may be, and interblendings must be made between these and other thousands as the years pass. The very complexity of it all is

bewildering, and always the wonder grows that order may at last be brought out of such seeming chaos.

In these tests, Mr. Burbank discards absolutely all antiquated notions, like that, for example, which provides for tissue paper bags to encase newly pollenated flowers, proceeding upon exceedingly simple, sane, and effective lines. He lays particular stress upon this in his cactus breeding, noting that it is not only wholly unnecessary to put a flower in a pocket at a most critical time in its life, but that it is positively harmful to the flower, preventing its fullest and most satisfactory development. He says there will be no question as to results, practical or scientific, if the person who does the pollenating knows his business: this being granted, nature will take care of the rest.

Following the pollenating come the culture and care of the plants until seed-growing is accomplished; then new seeds must be planted, new flowers must blossom, new crosses must be made.

But correlated in importance with all this is selection. There must be a constant scrutiny of the new plants as they come along in

successive generations. Crosses must be made with allied and widely separated species; crosses with those most intimately related; crosses between different varieties of each species, a very close and intimate in-breeding, so to call it, but selection must at the same time be rigidly practiced, or the test will utterly fail. Over six hundred varieties and over seventy-five species have been used in the prosecution of this test covering the twelve-year period it has been in progress, always with two elemental needs before the mind:—first, so to blend these plants having diverse and similar attributes that they may be able to rid themselves of their old wild ways and of their old imperfections; second, to build up a race of new plants, hardy, prolific, thornless, nutritious, of help to the race.

All this has constantly been before Mr. Burbank's mind in carrying forward this, in many ways, the greatest act of his life. Out of the wild, barbaric chaos of a plant life arrayed for centuries, indeed for how many milleniums we do not know, as a distinct foe to all animal life, he has brought a fine and beautiful order. From one plant he has taken strength, from

One of the new Opuntias four years old, eight feet high, bearing over four hundred pounds of fruit. Half of one leaf put in the ground in April produced over sixty leaves by the middle of September.

another beauty of flower and form, from another abundance of fruitage, from another prodigious powers of growth, from another intense persistence, from another adaptability, from another hardiness. From them all he has moulded the new plant, fashioning it through long patient years of care and toil and physical discomfort,—for the work among the wild cacti, and particularly the pollenating, is accomplished in the midst of sharp pain, the thorns inevitably working their way into the fingers and causing much distress,—often interrupted by discouragements and blocked by many failures, but always pressing on with supreme devotion and an unconquerable confidence in the final outcome. While out of the thousands of crosses that have been made many strange and fearsome plants have come, intensifying with pagan persistence their devotion to the gods of pain and misrule, yet steadily the nobler traits have predominated until the long-sought end has been reached.

Six new opuntias have been produced as a result of all these twelve years of labor, thornless save in one or two instances, where the thorns or spicules are so insignificant as to be

of no danger. These six are creations; let this be clearly set forth, new plants, actually made by Mr. Burbank from material never combined before, the product of his brain and hand, plants different from any ever created before by man or nature, set forward for the enrichment of the race.

Briefly noted, they are the "Santa Rosa," producing leaves more rapidly than any other cactus plant Mr. Burbank has had in his whole collection wild or cultivated, the leaves often two feet long by ten inches wide, producing in three years from the seed a plant six feet high, six and one-half feet across, with seventy-one huge leaves; the "Sonoma," producing leaves very rapidly and thicker than any of the others; the "California," quite similar to the "Sonoma"; the "Fresno," a cross-bred seedling wholly unlike its parents and, though but two years old, having leaves eighteen inches long by eight wide; the "Monterey," the most rapid-growing of its class (Tapuna) with nearly circular leaves, thick and ten or twelve inches across in yearling plants; the "Chico," especially strong in fat and starch content.

Only the barest outline of their individual characteristics may here be given.

Along with the production of these entirely new opuntias has gone the development and improvement of old varieties. These have been advanced by constant selection and crossing far beyond the point they had reached unaided by man, and extensive tests are still in progress among them. It is of interest to note that one or two of these latter which were recently discovered by an agent of the government in a foreign land, and brought to this country for experimentation, had already been under test in Mr. Burbank's proving grounds for years, while another, thus discovered and brought to the United States, practically identical with them, had been growing in California for over thirty years.

In order to secure definite data as to the composition of the cacti under test, Mr. Burbank submitted a number of the new opuntias to Professor M. E. Jaffa, of the Department of Chemistry in the State University of California, a very careful analyst. His analyses are here given, supplying important information on this point.

Analyses of Four Samples of Thornless Cacti Received from Luther Burbank, Santa Rosa, California, February 8, 1907

	Santa Rosa Per cent	Sonoma Per cent	California Per cent	Chico Per cent
Water	94.70	94.66	94.01	92.74
Ash	.96	1.23	1.35	1.68
Protein	.66	.72	.61	.58
Crude fiber . .	.75	.59	.54	.75
Starch, etc. . .	2.88	2.71	3.45	4.06
Fat	.05	.09	.04	.19
	100.00	100.00	100.00	100.00

It is of interest to note, in this connection, that the national government, through the Bureau of Plant Industry of the Department of Agriculture, has lately been engaged in cactus tests to determine the food value and general composition of various wild cacti. The results have been highly encouraging. In a bulletin issued by the government in the present year (January, 1907), by David Griffiths, of the bureau, and R. F. Hare, chemist of the New Mexico College of Agriculture, certain important results are shown. Elaborate analyses were made of the wild cacti, the opuntias, the type upon which Mr. Burbank began his work to develop them into the present thornless ones. It was shown in this coöperative examination that there was a marked difference in

the amount of water held by the cacti in wet and dry seasons, running as low as 60.99 per cent and as high as 95.5 per cent. On the point of a balanced ration for stock, with the wild cactus as a factor, the bulletin holds that, so far as has been determined, a ration of the wild cacti for a cow would require 40 pounds of cactus with 10 pounds of wheat bran and 12 pounds of corn stover, giving the cow 21.16 pounds of organic matter, containing 1.68 pounds of protein, 11.82 pounds of carbohydrates and 0.49 pounds of fat.

It is shown in the bulletin that at a recent test, conducted by the Bureau of Plant Industry at Encinal, Texas, a ration of prickly pear and cottonseed meal was fed to a bunch of steers for one hundred and five days with a gain of one and three-fourths pounds of flesh per day at a cost of only three and one-third cents. "Any ration of these two foods," the bulletin says, "that would secure this gain each day, would contain an excess of proteids over an amount necessary for a balanced ration. Fortunately, however, an excess of proteids can be utilized in serving the function of the carbohydrates in the animal body,

and this is, no doubt, what took place in the above experiment."

Attention is called in the bulletin to the use of the prickly pear in Mexico where the thorns are singed away before feeding to cattle, though the interesting fact is developed that, to quote from the bulletin, "the extent of cattle-feeding upon this kind of food is not so great in Mexico as one would suppose, from the abundance of the material and the great extent of time during which the practice has been in vogue. The fact is, that the average Mexican peon cannot afford to feed to stock what he himself can use so profitably in other ways. The prickly pear is to him primarily an article of human food, and its place cannot be taken by any other plant. . . . Over a large part of the Republic, although the prickly pears are much used for forage, their principal use is as an article of human food."

While this is a new departure in this country in the line of animal feeding, and while much remains to be worked out, enough has been established to show the large economic importance of the cactus as a forage food.

Now that Mr. Burbank has taken this wild cactus and developed it as here set forth, preserving and enhancing its desirable characteristics and eliminating its objectionable ones, the whole situation is simplified: his new cacti enter, figures of commanding importance. Instead of attempting to devise mechanical or other allied means for the removal of the dangerous thorns and spicules, he has removed them by breeding, while, at the same time, enormously improving the general character of the plant.

This leads to a consideration of the producing powers of the cactus as compared with other forage foods. During the past summer, 1906, the new opuntias which Mr. Burbank has created produced in the first six months of their life, from single-rooted plants (this in a climate and soil supposed to be poorly adapted to the cactus), forty-seven and one-half pounds per plant, yielding at the distance planted,—in rows five feet apart and with plants two and one-half feet distant from each other,—at the rate of 180,230 pounds per acre. This is over ninety tons per acre. The second and succeeding years the opuntias are

always expected to produce about double as much as during the first year. While Mr. Burbank does not expect more than about one-fourth as large a yield as this on a desert soil without irrigation, say, at a conservative figure, twenty tons per acre, he does expect nearly or quite twice as much,—from one hundred and fifty to one hundred and eighty tons per acre,—in a very warm climate with perhaps one or two light irrigations per year.

These figures give something of the enormous economic importance of this new plant for forage. The average yield of clover, alfalfa, timothy and the like, is not at the outside more than one-fortieth as large as the yield already established at Mr. Burbank's grounds in soil and climate, as indicated, not supposed to be particularly favorable to cactus-growing. While the leguminous plants, as alfalfa and clover, are richer in protein than the cactus, and while they will doubtless never be displaced altogether because of their value in helping produce a model balanced ration, yet the vast difference in the yield suggests how very great is to be the influence of this new plant upon the feeding of animal life. It is of

interest to note, however, in this connection that, working along the line of inducing condensed nutrition, Mr. Burbank may produce, by breeding and selection, a cactus having all other desired characteristics and as rich in fat, starch and protein as the richest legume. This is but a logical and natural development; he has followed similar tests in other lines to successful ends.

But the first thing to be done was to develop from the wild cactus a thornless, spiculess, fast-growing cactus, suitable the world over for a forage plant for animals and producing excellent food for man. This has been accomplished.

If you stand some summer day before a field of alfalfa, or timothy, or any other hay-producing grass or grain, consisting of say a hundred acres, you may look for a harvest in normal years of from a hundred and fifty to two hundred tons,—perhaps, with copious irrigation in the case of alfalfa, as high as five hundred tons, though this would be a rather liberal figure for a good many regions without an unusual amount of water. If you could stand before a hundred acres of the new thorn-

less opuntias, growing in such splendid fashion as those which are now growing (March, 1907) in Mr. Burbank's proving grounds at Santa Rosa and Sebastopol, tall, upright, immense plants, tropic in their luxuriance, but firm, strong, vigorous and healthy, you would see a field producing not two hundred tons per season, nor even five hundred, but nine thousand tons per season,—under specially favorable conditions of climate, soil, and irrigation, fifteen thousand tons. Does this not suggest something of the enormous scope and influence of this mighty new force in plant life?

As in the case of the fast-growing walnut trees, described in another chapter, there may be people who will consider such a statement overdrawn or chimerical, but the same answer will apply in the one case as the other. The trees with precisely the same wonderful characteristics are now growing, living evidence, while the cactus plants are growing in splendid strength just as here described, and with just this magnificent promise of help for the race. The fact is that just as Mr. Burbank, in the development of the scientific side of his work, has accomplished things scientists have

over and over again pronounced impossible, just as he has set aside some pet theories, because in his life-work he has had such opportunities to test and prove and observe as no other man living or dead has ever had, enabling him on this unprecedented scale to detect the errors that have arisen from tests made in a petty way, so in the practical side of his work, like that in the fast-growing trees and the new cactus, he has demonstrated to be fact that which practical men, sincere to the core but having inadequate knowledge, have believed to be impossible.

It is extremely interesting to note in passing that Mr. Burbank has received numerous letters from various desert-like places in the world, and from regions where Famine stalks, asking,—indeed, it might sometimes well be termed pleading—for information as to the new cactus, the hope of the desert world. Recently a communication was received from the representatives of the British government in India, making enquiry how this new cactus may be introduced into the famine-stricken regions of that land. Once established on a large scale, the new cactus may remain for

years uncultivated and undisturbed, constantly growing on and adding to its vast store, so that, should famine come, it is ready with food for man and beast, each acre thus being able to preserve the lives of hundreds of human beings for months if needful.

Reference has been made to the use of the wild cacti as a food for animals after singeing the thorns with fire. On this point Mr. Burbank says:

"Those who have fed the wild cactus extensively acknowledge that cattle are often seen with blood dripping from their mouths, and that their throats and tongues become inflamed, very painful and at last like a piece of sole leather. How would you enjoy being fed on needles, fish-hooks, toothpicks, barbed-wire fence, nettles and chestnut-burs? The wild thorny cactus always has been and always must be more or less of a pest. The best newer thornless ones will withstand frost, flood, drought, heat, wind and poor soil as well as the wild ones, and will produce ten tons of fairly good food, where the average wild one will produce one ton of poor food."

The fruit of the new cactus has steadily

An illustration of the prolific nature of the new Opuntias,—thirty-two fruits growing upon a single leaf

improved also under treatment. It will bear its full share in the regenerative work in progress, not supplanting the earth's fruits, but supplementing them. As in the case of other tests of fruits, Mr. Burbank has followed the methods set down in the chapter dealing with his plan books. I saw in his office among the records of his work on the cactus a bundle of leaves bound together, each one bearing in its upper left-hand corner the imprint of a cactus fruit. Each fruit under test is halved and pressed down upon the page so that its actual dimensions and general shape may be outlined. The seed cavity is also defined. The color of the fruit, pink, crimson, orange, pale yellow, or what not, was clearly to be seen where the meat had touched the paper. The fruit promises much in a commercial way also, since it has from 12 to 16 per cent of sugar in its composition, and in the case of the new opuntias is a heavy bearer. It promises to take its place in the ranks of the apple, peach, plum, and all those fruits which have fought their way up to their present satisfactory stage, though absolutely distinct from them in character, form and taste.

Before giving details from Mr. Burbank, as to the best method of planting and caring for the cactus, one important point must be indicated. While the new cactus is not so rich in starch as some other plants, its enormous yield per acre provides a large amount of material which is fermentable and which thus promises to become available for the production of ethyl alcohol, denatured alcohol, which is now to come into such general use and for such a variety of purposes through the action of the government in allowing its manufacture without tax. Experiments have been carried on at the New Mexico College of Agriculture to determine the amount of fermentable material in the wild cactus. It is shown by way of comparison in the reports recently issued as a result of the experiments, that the average yield of corn throughout the United States is about 1,613 pounds per acre, containing 1,129 pounds of fermentable material convertible into 80.64 gallons of alcohol, worth, at the current price of the denatured alcohol, 40 cents a gallon, or $33.25 for the acre. The experiments at the New Mexico College were conducted under unsatisfactory

conditions owing to various causes, chief among them being the lack of data as to the cactus from which to work.

However, taking 10 per cent as the amount of carbohydrates in the cacti analyzed, although it was not known how much of this would be fermentable to form alcohol, it was shown that on an estimated yield of 73,000 pounds of wild cacti per acre per year, 360 pounds of carbohybrates would be produced equivalent to 521 gallons of alcohol, worth, at the price quoted, $208.40. The bulletin issued by the college sets forth that this yield, 36½ tons per acre, of the wild cactus is probably too high.

Mr. Burbank, as noted, has created a cactus out of this wild cactus with a demonstrated yield under indifferent conditions of ninety tons per acre. This, too, for the first year, the very lowest output. Under the most favorable conditions, a yield of fully one hundred and seventy-five tons per acre seems assured, this with soil and climate exactly adapted to the production of the cactus at its highest. This, on the basis of the experiments at the New Mexico College, would mean for the

highest yield a return of at least one thousand dollars per acre in material for the manufacture of denatured alcohol. Taking the demonstrated yield of the new cactus per acre under indifferent conditions, and upon this basis the revenue would be two and one-half times as great as that from the wild cactus as indicated by the college figures, or $520 per acre in denatured alcohol as against $32.25 for Indian corn.

In considering these figures, as to the new opuntias, it must be borne in mind that, as in the case of the data regarding the fast-growing trees, all former standards of measurement must be abandoned, so tremendously have these new forms of plant-life eclipsed all others of a corresponding type. These new and powerful factors in the plant life of the world are unique. They afford data for the readjustment of many of the world's great forces. The way is opened in the one case to the rapid re-foresting of the earth's denuded areas, while in the other case, in addition to providing limitless stores of food for all climates and all regions, desert or arable, it also promises to provide a remarkably cheap and

inexhaustible fuel, as well as limitless supplies of material for all the many needs to which crude alcohol may be applied.

The more the great work of Mr. Burbank is studied, the more clearly does it appear how grandly it transcends all other work in the domain of plant-life. Great as has been his influence, it has but begun its service to the race; its sweep is limitless.

"Plant wherever you wish to have them grow," is Mr. Burbank's advice as to the new cacti, "on rich level land, or the steepest, poorest, rocky hillsides, in old river beds or rock piles. But their growth and succulence are naturally increased by good soil, some culture, and, in very dry soils, by one or two light irrigations each summer. By such treatment, the fruit is greatly increased in size and quality, and the slabs for feeding are doubled in weight and succulence. Nothing responds more promptly to fairly good treatment. They will flourish almost anywhere except where it is too wet for anything too grow.

"Unlike most plants, the opuntias root best during the heat of summer, and this is also the best time to transplant them. They should

not be moved at other seasons. No one who is familiar with them would undertake to root or transplant them during cold, damp weather such as would be best for other plants and trees. During June, July, August and September they will thrive under any treatment; the leaves, blossoms, buds, half-grown fruits or any part of the plant will take root and grow, even on the back of a cook-stove, in the pocket of your winter overcoat or on your writing-desk. The opuntias differ astonishingly in hardiness. Some strains of the common prickly pear (*Opuntia vulgaris*) will grow readily in Alaska, and several of the thorny species will endure forty degrees below zero without injury. The best agricultural and horticultural varieties are not quite so hardy as the fig, yet are still more so than the orange, lemon, lime or common blue gum (*Eucalyptus globulus*)."

Mr. Burbank enumerates the various uses of the new opuntias as follows:

"The plants may be used for hedges or fences as well as for ornament. The leaves are a food for all kinds of stock, including poultry. The fat young leaves (joints) make most ex-

Thousands of tender cactus seedlings just out of the ground, overtaken, but uninjured, by a severe snow-storm,—a proof of their hardiness

cellent pickles and are a good wholesome food when fried like eggplant. They are also boiled and used as greens, and when prepared with sugar produce a sweetmeat similar to preserved citron, and may be flavored with ginger or other spices. The abundant mucilaginous juice from the leaves is extracted for mixing with whitewash to make it more lasting when exposed to the weather. The fresh fruit of the improved varieties is unique in form and color, bringing a price about the same on the market as oranges. It can be produced at perhaps one-half the expense of oranges, apricots, grapes, plums or peaches, there being no failure in the crops, and the fruit can be shipped as safely as the other deciduous fruits. The juice from the fruits of the crimson varieties is used for coloring ices, jellies and confectionery."

The following directions are given by Mr. Burbank for planting:

"The opuntias differ from nearly all other plants, as the cuttings must first be wilted before they will grow, after which nothing grows so readily. When received, put them in some warm, sunny place and allow them to

remain a week or more, after which they will readily form roots and start to grow anywhere, even on a board, a pile of rocks or the roof of your house if you choose. When wilted, the usual way is to plant so that about one-third of the cutting is below the soil. They may be planted in an upright position or at any angle from the perpendicular; it makes no difference to the opuntias. On fairly good soil in general field culture for stock feed, the giant-growing kinds should be planted about three feet apart in the rows and the rows should be about eight feet apart. In orchard planting for the large-growing, fruiting varieties, probably four by ten or twelve feet would be better."

So the new cactus goes to the world after many years of exacting study, exhaustive experimenting and searching tests. From the commercial standpoint, from the standpoint of those who live and die where Famine stalks, as well as from the point of view of those who, from economic reasons, would see the vast waste places of the earth made fertile, this is certainly the most commanding act in the life of the world's greatest constructive plant-breeder, an act of splendid usefulness.

CHAPTER XXIV

THE NEW WORK

IN considering the new work now in progress, may this word be said in Mr. Burbank's behalf: He has made a decision not to answer any correspondence relating to the details of new work under way. The volume of his correspondence is so large, the demands upon his time and strength are so great, he is obliged to make this imperative. He has been compelled, also, especially since the administration of the Carnegie grant began, to restrict more and more the number of visitors at his home in Santa Rosa, not from selfishness,—quite the contrary indeed, for he much appreciates the widespread interest in his work and would be glad to admit everybody; but, in order that the work under way, which is larger in scope than any which has preceded it, may not be retarded by interruptions, few, if any, visitors are now admitted to his grounds without first arranging by letter for permission,

while still fewer people may meet him personally.

In presenting this view of the new work under way by Mr. Burbank, one is impressed not only by its great signifieanee but by the variety of the tests in progress. It had been Mr. Burbank's hope that, under the Carnegie subvention, he might eonfine himself to fewer tests, and, to a certain extent, this has been effeeted, but, at the same time, while some smaller tests have been temporarily set aside, the seope of the new work has been greatly enlarged. On his proving grounds at Sebastopol and Santa Rosa there are upwards of three thousand distinct tests under way, embracing more than a million plants coming forward under the direetion of the man who has already brought so many commanding tests to a suecessful end.

In revisiting the proving grounds at Sebastopol, where the larger work is ehiefly in progress, one is at once impressed by the widening of the seope of the great enterprise. More aeres have been added, more men set at work, better opportunites are offered for advaneing the tests to sueeessful eulmination. Even, if

I may be pardoned the diversion, even the great earthquake of April 18, 1906, gave its aid, for not only was not a single plant out of the hundreds of thousands injured, but this curious thing happened: In plowing between the long rows of plants and young trees extending down the field sometimes half a dozen city blocks in distance, great care must be exercised by the workmen to throw the earth to the center away from the roots; after which it must be broken up and leveled again. The entire area had thus been plowed and was ready for the workmen when, in less than a minute's time, the mighty unseen power picked up the world and shook it as a man would shake a sieve between his knees and the clods of earth were broken up and leveled over the entire plowed area and settled into place even more skilfully than the workmen could have accomplished it. Nor was a single pane of glass cracked in his conservatory, nor did one of his chimneys fall, though all but some dozen or so in the little city were destroyed. Stranger still, a collection of some five hundred negatives illustrative of his work, which had been accumulating during the years and

which were stored at a local photographer's, escaped without a scratch, only two unimportant ones being broken, while the entire stock of the photographer was destroyed in the collapse of the building, leaving only a mass of broken glass. Mr. Burbank's negatives were found lying in the debris unharmed.

Taking a general view of the work under way, it embraces several hundreds of thousands of new hybrid plums out of which some striking results are promised; some eight thousand new hybrid chestnuts made by crossing Italian, Japanese, Chinese and American varieties; the same number of new hybrid walnuts, blendings of the American black walnut, the Sieboldi, the English walnut, combined with the Manchurian butternut; fully as many thousands of new seedlings of the pineapple quince; thousands of new peach and peach-nectarine crosses; at least ten thousand new hybrid seedling potatoes, some of them very rare, with thousands of plumcots, apricots, cherries, grapes, berries of various kinds and the like, and extensive tests in the line of new and improved grasses, with several thousand cactus plants undergoing tests.

The Gold plum, first Japanese-American hybrid plum;
a rare fruit

This will give a general idea of the vast scope of the work now under way. These thousands of plants are being cared for with the same close watchfulness that has marked Mr. Burbank's breeding tests from the start, and where the details of the work have increased beyond the reach of any one man's powers, he has men trained in his own great school of experience, who are competent, under his close supervision, to carry on the part of the work delegated to them.

Passing more into detail, it may be noted that the approach to a test may be from a variety of avenues. Sometimes it comes along the way of a suggestion, though Mr. Burbank has clearly defined lines of his own, marked out always years in advance; sometimes it may come through the offering of some new plant by one of his collectors, a plant which the collector has found growing in some distant part of the world and which he thinks might be improved; sometimes it is a volunteer suggestion from some person Mr. Burbank has never heard of. While some most preposterous and laughable things are included in this latter class, now and again one comes

which has distinct value. Such was the case when an unknown friend sent him a few seeds from a blackberry, which had no thorns and was said to grow luxuriantly, but which was good for nothing as a fruit. To the average man, to the average plant-breeder or nurseryman, indeed, such a gift, however well meant, would scarcely seem worth more than a note of acknowledgment for the thoughtfulness in sending it.

But Mr. Burbank's vision is not bounded by the limits of the apparantly impossible. Before he abandons any test he first determines for himself, without any reference to preconceived notions, or so-called laws, or beautiful theories, whether or not the test may be followed up to a successful issue. So, seeing the possibilities in this instance for making over the fruit, he welcomed the worthless berry seeds and set about testing whether they might not be the forerunners of a race worthy of instalment among the proved fruits of the world. There were but a few seeds in the letter which came, not more than four or five hundred all told, but they promised to be the progenitors of a powerful family. When the

few seeds came up out of the ground three or four little plants were selected as being worthy of further test, and their seeds were again planted. This larger outcome was satisfactory from the standpoint of thornlessness, for the new generation persisted in this desirable quality. But the fruit was no better, small, sour, big-seeded, absolutely worthless.

The following year a much larger number of plants were afforded for selection and the present season, 1907, twenty-five thousand absolutely thornless blackberries are growing on the grounds at Sebastopol in the midst of one of the most interesting tests Mr. Burbank has ever carried forward. While, as the test progresses, undeniable excellencies appear in certain of the berries of the new plants, as compared with the berries when the test began, some larger, or having smaller and fewer seeds, or slightly better in taste or color, and while a perfected berry could no doubt be effected by constantly making selection of these slightly improved berries and so building them up year by year, yet whenever, as in this instance, there is a shorter route, safe and well guarded, Mr. Burbank always takes it. So in

this case he has begun this shortening by the introduction of a better berry-producing strain of blood. Selecting the very best of the thornless berries, these are crossed with choice varieties of blackberries now known, in order to give to the berry-to-be, size, flavor, richness, color, general excellence. It is not unlikely that the newly created berry may be even better than any of its best ancestors, in addition to its thornlessness, for it brings to the test great hardiness and virility. The best offspring of the crosses with the berries of better fruit are in turn selected and so on as the test advances, always making selection of the very best and making no combination or blending which does not promise some pronounced excellence for the new fruit.

So, within a few years the test will be perfected, just as hundreds of others have been perfected, and there will come into common use a series of fine new thornless blackberries, making their compelling appeal to all of us who would prefer to have our berries without their exasperating thorns.

Brief reference was made in a preceding chapter to the work which was under way at

The large plum to the right is the result of a cross between the wild American beach plum, at the left, and a Japanese plum. The new plum is much larger than here shown and twice as large as the Japanese parent.

the time the chapter was written, on the new fruit which has been called the pomato, which develops from the seed-ball upon the potato into a fruit of the general size and shape of a small tomato. The work in progress since the pomato was established as a definite, though unperfected fruit, has been interrupted by many other more pressing duties. As the test advanced, it was found that to make the fruit perfect and appropriate for general introduction, certain tendencies must be overcome. When grown from tubers, it produced less and less fruit each season. When raised from seed, there was almost a constant reversion to the common bitter potato ball as of old. It will be necessary to fix it by numerous selections in its best estate which has been already secured, but the time required and the great number of seedlings necessary thoroughly to fix the tendency to bear delicious fruit, make the work too great at present for Mr. Burbank to undertake with all the other work in hand. The time will come when either he or someone else will make a stable, abundant fruit out of the pomato, already proven to be a most delicious fruit.

While this test has been checked merely for the reasons noted, it may be well here to say, in answer to those wild and silly claims that, from time to time, have been made by irresponsible persons as to miracles performed upon these great proving grounds, that Mr. Burbank has never sent out to the world any creation which was not, in so far as it was possible to make it, perfect, complete in all its appointments, standing for just what it was by him represented to be, nothing more nor less. Should he at any time in the midst of a great test, covering, it might be, a long term of years, discover that the test was not going to come out as he had hoped, he would be the first to abandon it. He has been scrupulously careful never to present to the world any production in anything but its right light. I recall passing by a florist's stand in the city of San Francisco one day, and noticing prominently displayed "Burbank's new green carnation," the product of a very ordinary white carnation and a bottle of ink. Many such spurious things have been exploited under his name, and it will be worth while, when reading some *bizarre* statement of his production of some

floral impossibility, to bear in mind that nothing leaves his hand which is other than he represents it to be.

In a previous chapter mention was made of the transformation of the wild American beach plum, a small, bitter, comparatively worthless fruit, into a fine new plum, having desirable attributes and maintaining the prolific bearing qualities of its hardy little ancestor. As work has progressed upon this plum, it has wonderfully developed along the line of size. Mr. Burbank has crossed it with a Japanese plum, and, while the statement seems little short of miraculous, the fact remains that the new plum is fully five hundred times as large as the beach plum from a seed of which he began the work several years ago. It is one of the most wonderful instances of development ever known in plant-breeding.

Mention was also made of a pitless or stoneless plum which Mr. Burbank has produced from a tiny French plum about the size of a cranberry, and having only a portion of a pit. It was shown that it only remained a matter of time to breed the stones out of all plums and prunes. In line with this comes the new

and important information that Mr. Burbank now has growing in his tests fully five thousand varieties of stoneless plums all waiting for the final selection of the best, some of them already showing superb quality. This is one of the most important features of the new work in progress. The first announcement of the production of a stoneless plum was strikingly interesting from the standpoint of novelty, something, to many, hard by the land of miracles, but now the commercial importance of the new plums looms high; for, with the general use of plums and prunes having no stones, this whole department of the world's fruit industry will be changed. These five thousand pitless seedling plums mark a revolution, or, better put, an evolution of immense significance.

It must be borne in mind that in producing a new plum, bringing it up to a final perfected condition, years of time are required, and particularly so when so important a change as this is to be made. Melons, corn, beans and the like, can be brought to test in six months' time, not so with a tree.

In the line of new fruits, Mr. Burbank has

been at work upon a most interesting problem, now solved, the production of a fruit from a cross of two solanums, the widely differentiated plant which runs through some seven or eight hundred species, chief among which are the potato, the eggplant, and the deadly nightshade. The two plants on which Mr. Burbank has been working bore what might be called fruit, though neither one was of any value. One bore green berries about the size of buckshot and of no use whatever as a food for man, though animals are very fond of them, especially rabbits and poultry. The other bore somewhat larger fruit, black in color, growing in smaller clusters. This latter had an intensely bad odor and flavor and was of no value as a food.

These two worthless plants were crossed, and out of them has come an entirely new fruit, different from any which has been known in the world before, and promising to become a novel and valuable addition to the world's store. Work is still in progress, as the plants vary somewhat in flavor and productiveness and uniformity must be secured. But so great is their general productiveness that

none of them has failed to bear more fruit than almost any other known fruiting plant. The marvelous bearing qualities of the new fruit will be among its chief commercial recommendations, but coupled with this is delightful flavor and attractiveness of appearance. The new fruit varies from the size of a large blueberry to that of a large huckleberry, and is, curiously enough, the exact counterpart in every possible particular of the common low-bush blueberry, the *Vaccinium Pennsylvanicum.* Mr. Burbank says that no person could possibly detect the difference between the two eaten in a pie or, as so many prefer, in a bowl of milk, and yet the two plants are wholly separate from each other. When cooked for use as a sauce or for other forms of dessert, the new fruit does not differ in appearance or taste from the blueberry. The seeds are no larger than the blueberry seeds.

But the best quality of all is their enormous productiveness. The plant will continue bearing successive crops all summer, and until winter, appearing in fine large clusters. In such climates as that of California, the bearing continues through most of the winter. The

A field of the new crimson poppy, the native California golden poppy, which Mr. Burbank changed from yellow to red

plants are raised in the same way as tomatoes. Mr. Burbank points out the fact that a man can now raise blueberries (or what is their equivalent) in his back yard as cheaply and easily as he can raise tomatoes. In acre lots the new berry promises to have important commercial features, making it, indeed, a large factor to be reckoned with in the future of fruit-growing in America and in all the rest of the world as well. Mr. Burbank says it must not be confounded with a so-called "garden huckleberry," *Solanum nigrum*, or black nightshade, having a most disagreeable taste and an offensive odor. Any one, he says, who can eat a second berry has unusual courage.

Allied with the production of this new fruit is the work upon the bitter elderberry, which has for so many years been valuable chiefly as a remedy for certain diseases and sometimes used in the making of pies, in the manufacture of wine and for use in the adulteration of port wine. Mr. Burbank some time ago began work upon a bright yellow variety from which he produced some thousands of seedlings. Out of the thousands one was discovered which had a quality that he much desired—it

was free from the bitter taste of its ancestor. Slowly he led it upward by successive selections of the very best of its progeny, always with the one end in view to intensify its good attributes and exclude its disagreeable ones. The result is that he has produced a fruit with not a trace for all time of the bitterness of the old berry, as white as the Niagara or any other grape that can be named, and as delicious as the grape, when cooked or when dried as a raisin.

But even this does not satisfy him, and he is now at work upon thousands on thousands of seedlings to make still further improvements. It has been for forty years Mr. Burbank's ambition to take this plant of so little value commercially and so inferior, or even worthless, as a fruit, and transform it into a fruit which should enrich the world. Enough has now been proven to show that he has the end in sight. He has verified his position step by step, leaving nothing to conjecture and refusing to allow it to leave his hands, even in its present advanced stage, preferring to wait until still further improvements are effected.

Among the curiously interesting tests now

To the left, the leaf of a wild geranium as Mr. Burbank found it; to the right, the leaf as he left it after years of selection for greater beauty. The single leaf shows the change even more markedly.

well under way and promising rare results is the work upon a new edible passion-flower fruit. When at Sebastopol I found one workman upon his knees in the midst of a long row of low vines, industriously cutting away the long runners or branches and pruning the plants into shape for another season's work. I noticed that the plants growing so thickly upon the ground bore numerous green balls, usually somewhat elongated and about the size of a hen's egg, some of them larger. The plants were still green, though many dead leaves were being raked out. They grew close to the ground, quite as a melon grows only with shorter stems and much more numerous in leaves.

It was very difficult to realize that this low-growing, industrious-looking plant, which was being so severely pruned, was the passion-flower plant known by this name since the day when the first Spanish settlers in America discovered it, and saw in its curiously interesting flowers a representation of our Lord's passion,—the slender filaments of the corona the crown of thorns, the styles the nails of the cross, and the five anthers the marks of the

wounds. The five sepals and five petals were also taken to have a special significance, representing the ten apostles, with Peter, who denied his Master, and Judas, who betrayed Him, left out. The flower was given some very curious pictorial interpretations by the botanists of the sixteenth and seventeenth centuries. In some parts of the world certain varieties have been grown for their fruits, which are unlike in the different varieties in shape and size, running from the size of a hen's egg to that of a gourd, the latter sometimes weighing from seven to eight pounds. But it has oftener been as a flower, not as a fruit, that the plant has been noted; indeed, it is quite likely its former use has been unknown to many who have long admired it for the peculiar beauty of its flower. Now that through the improved variety a valuable fruit is to come into commercial prominence, the passion-flower takes on a new interest. It has been cultivated for years in many quarters of the globe for its peculiar beauty and for this strange religious association. Ordinarily one sees it rambling over a porch or growing on a trellis or clambering up a huge tree-trunk, its

brilliant curious flowers of the numerous species always objects of admiration. To see it prone upon the earth not more than six or eight inches high, growing in long rows, with the pruning shears severely cutting it down, is to receive an altogether different impression of this really wonderful plant.

Mr. Burbank now has a great number of hybrid passion-flowers raised from thousands of seedlings of selected varieties, and the early promise of adding a list of improved varieties of most delicious fruit, should just the proper combination and blending be effected, is now being fulfilled. It will be some little time before his new edible passion-flowers will be on the market, but enough has been already accomplished to assure success. It is of interest to note that some new varieties of the passion-flower never before known, and not even classified by botanists, are among the ones on which he is working in building up the new fruit.

Not ready for announcement are several absolutely new fruits upon which he has been at work for years, promising some singularly interesting and important results. An entirely

new poppy, rarer, in some ways, than any he has yet produced, is under way, receiving now its finishing touches before it goes out in radiant beauty to adorn the world. Mr. Burbank says that this new poppy promises to surpass in size, color, gracefulness and general beauty any poppy now known in the world. The experiments in new forms of grasses which have been much interrupted in their progress have now been resumed. Along this line the economic results promise to be large. Attention is now being given to one important department in which Mr. Burbank has been at work, but never to the same extent as in other lines, the production of more beautiful and striking flowering shrubs and ornamental trees for lawns and public parks. Some tests, promising most effective results never before reached in this line, are under way.

In this latter connection I may make mention of one of the rare acts in his life,—so far as I know it has not been publicly announced,—the complete changing of the leaf of a wild flower from a plain, unbroken edge to a most beautiful fringed effect, transforming a homely wild plant, growing neglected on the California

hillside, into a beautiful decorative plant, very effective when potted for indoors in wintry climes and for outdoor use along garden walks or in masses. The transformation was effected by insistent and long-continued selection, forever choosing from the new generations of plants as they came along those whose leaves approached, even if slightly, the effect desired. In this way the completed plant has been secured. The accompanying illustration shows how marked has been the change wrought.

While the new work in progress is being greatly aided in its practical aspects by the Carnegie grant, the scientific side of the new work is not being neglected. The Carnegie Institution authorities are taking a deep interest in the work, and a man has been detailed to make an accurate and extensive review of all the work Mr. Burbank has done in the past, as well as to record data as to the work in progress. In the midst of great toil, and often working under severe mental strain, it has been impossible for Mr. Burbank to make as extensive detailed records of much of his work as he would have liked to do. Now,

however, this is being effected and a rich store of technical and general information is assured. One feature of particular interest is the preparation of what may be called a life history of plant-life. Once a day Mr. Burbank meets the representative of the Institution with a stenographer. Beginning with the first letter of the alphabet the whole field of plant-life is being considered. Taking up each plant, questions are asked, if necessary, though often Mr. Burbank dictates without questions, thus recording information regarding all phases of the plant's life as he has observed them through the years. Coupled with this in the case of those plants upon which he has actually worked, is a detailed statement of the process of his development of the plant. The plan is large in scope. It will be of special interest to all advanced plant-breeders as well as to botanists, physiologists and biologists. It promises to give to the world a mass of novel and immensely valuable information, for the source upon which the Institution is drawing stands unique in the world.

From time to time the Institution will publish the results of this most interesting and

important work. Though it will not be primarily prepared for the general reader, it must yet appeal to him, while its value as a praetieal and seientifie record of plant-life eannot be estimated.

In a eertain definite sense, Mr. Burbank's work is never done. He eompletes as far as possible, we will say, a plum. It has reached the very highest point to whieh, at the present, at least, for laek of time he has been able to advanee it,—in form, color, size, taste, riehness, shipping qualities and so on. And yet the very next year this plum may be superseded, or, at least, exeelled, in some one partieular point, by another plum which has been working its way up steadily through the years under the same guiding hand. So, year by year, new tests in plums are eulminating, and so large has been the preparatory stage that greater results are now promised than at any other time in the history of the work. Each year, too, tens of thousands are being diseardled beeause not superior to those now existing. It is Mr. Burbank's aim eonstantly to seek a higher plane. To him it matters not that a plant develops what might be termed speetac-

ular qualities, something brilliantly different; it must have abiding qualities, excellencies that lift it above all others, permanence. Nor does it matter to him how fine the ones that may have preceded it have been; the new one that is better must supplant them and inevitably will do so.

Just a word here as to some of the past productions of Mr. Burbank. It is so easy to forget. It is also convenient, sometimes. It sometimes becomes easy for a party possessing one of Mr. Burbank's productions to forget who made it, possibly it may be purposely given a name identifying it in some way with somebody who had no more to do with it than the prophet Jeremiah. In this way, in past days, many of the creations which he has brought out have never in any way been placed to his credit. Only the other day I chanced upon a current magazine article giving somewhat in detail the wonderful productiveness and general excellence of two of Mr. Burbank's berries. One of them was the Phenomenal berry described in another chapter, an absolutely new creation, one of the great triumphs of scientific plant-breeding, the other the really wonderful

Himalaya blaekberry, improved and introdueed by Mr. Burbank, now an aeknowledged standard of exeellenee. No mention whatever was made of Mr. Burbank in the paper. Such instanees as this are the more unfortunate, as they are exploitations, not advertisements, describing in detail for popular reading what new factors in Ameriean fruit-life are aecomplishing. Logically, in such a ease, the man who made them possible should eome first in their eonsideration.

Years ago, Mr. Burbank discovered and introduced a splendid plum which afterward took his name. At the first, nobody cared for it. Nobody eared for it even enough to use it free of cost. It aroused no interest. One day a rancher, living near Sebastopol, a man badly in debt and seeking some way of eseape, determined that he would give the new plum a hearing. He had seen it growing on Mr. Burbank's grounds and was impressed by its general excellence. All the land at his disposal, several acres, was given up to the Burbank plum. As soon as he had sufficient to sell, he found that the people who bought fruit knew a good thing when they saw it. The demand

rapidly increased. He sold at high prices. He devoted more space to the plum. It yielded him a handsome income, paid off a seven-thousand-dollar mortgage, made him independent. The late Cecil Rhodes heard of it. He introduced it into South Africa, giving it its chance to show what it could do on a hundred acres. It gallantly accepted the test, and from the hundred acres came a crop worth one hundred thousand dollars each year for several years.

But not a cent, directly or indirectly, has ever come to Mr. Burbank for this great plum, and he found it difficult in those first days to give it away. I fancy it would not be so today.

The new work as it progresses is steadily emphasizing the total inadequacy of the Mendelian "laws" (considered in the chapter on Mr. Burbank's theories and conclusions) when applied to actual breeding. The words which follow from Mr. Burbank on this point are particularly important because of the fact that they come from a man who has had greater opportunity, and on a larger scale, to study new forms of plant-life and observe the mani-

Two seedling walnuts, of the same age, from nuts of the same tree, having had precisely the same care: a striking illustration of unevenness in plant growth and of the importance of selection.

festation of Nature when her old ways are broken up than any other man, living or dead: it is the unparalleled scope of his work, coupled with the actual results he has observed, that make his words authoritative. He says:

"The total inadequacy of these 'laws' has been shown over and over again when applied to actual breeding. When they were first promulgated, the claim was often made that all plant-breeders must understand them or fail. How many plants of value have been produced by a knowledge of these laws? How many successful breeders worry themselves about them? No; these 'laws' have been shown not to apply, except in some rare instances."

In all the new work which Mr. Burbank now has under way, he is confirming and strengthening in superb fashion the positions he has taken, both scientific and practical. And while he believes with increasing earnestness, as the years bring their proofs, in the all-powerful influence of the Crossing of Species; while he pays deeper attention, year by year, to the mysterious and elusive phases of the manifestations of nature, ever seeking to strip

them of their strangeness; while he sees deeper into, and more broadly fortifies himself with, the immutable facts of heredity as it has appeared to him; while he goes still closer and closer into the life of the plants, measuring, defining, analyzing, he has, at the same time, neglected no sign nor cast aside any proof of the great fact of Evolution, nor has he hesitated to set apart and apply with his own hand means which Nature has so long made use of in her great scheme of the evolution of the plant, the human being, the universe.

A cactus blossom